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THE USE OF PROJECTS IN TEACHING NATURAL HISTORY SUBJECTS

BY W. WHITNEY
Botany Editor

The author's experience has been largely with botany, therefore we may be pardoned if we confine ourselves to this subject but the methods and suggestions used will apply equally well to other branches of natural history. A word may be well as to the use of the word "project." The word was first used, we believe, with classes in elementary agriculture to designate pieces of work undertaken by pupils out of class hours at home or on a designated plot of land. Some of these projects are well known, such as raising a calf or pig, planting and caring for an acre of corn, and many others of like nature.

It seemed legitimate to us to use the word to designate pieces of work in high school botany which could be done by the student independently at home or in the vacant lots or fields near his home. This work would be related to and supplement the work of the laboratory. It would, in a measure, take the place of "field work" under the supervision of the teacher and it would also broaden the work done in the laboratory and school room.

It is always difficult for the teacher with a class of twenty or more pupils on the field trips and often with a following of fifty or more in all his classes, to so conduct the excursions that the pupil's initiative will not be destroyed. There is a tendency to depend upon the teacher's eyes for things to see. In the case of the project study the pupil is thrown upon his own resources and his own brains. He learns to see and think.

The work in the laboratory follows a fixed routine and always there is little or no time to supplement this routine with illustrative or other material which will enrich and broaden the pupil's outlook and make the work more interesting.

Perhaps some examples of projects within pupil resources will help make this clear. In the fall there are the garden flowers and the autumn wild flowers. These should not be mixed. We have found that ten properly, named, dried and mounted specimens makes a good unit. For mounting we found plain paper of laboratory note book size most convenient. The specimens should include flower and leaf but never any root. Wild flower conservation can well be inculcated in this work. In the same manner there may be collections of weeds, using the fruit and seed in place of the flower. For naming plant specimens there should be at hand in the laboratory illustrated flower books—both garden and wild flowers—illustrated weed books, tree books, manuals, plenty of helpful books, so that the pupil's work may not become discouraging. Later, tree leaves and tree fruits make good projects. Some even enjoy making a collection of twigs of trees.

When the weather becomes too inclement for outdoor work, experiments and collection of fungi are in order. Growing the common bread mold under a glass tumbler inverted in a saucer is always very successful and interesting. We usually started the students in these experiments by inoculating the bread with spores from molds kept over from the preceding year. The experiments can be multiplied easily by varying the heat and light, omitting the inoculation, using freshly cut bread, etc. From this line of experiments one can easily pass to work with bacteria using potatoes and apples and various other media.

All this experimental work is done at the pupil's home, in this way interesting the parents in the work. Also the pupil is required to write up the experiment with drawings, the written work following the usual order in stating purpose, the preparation, what happens, conclusions. The paper is then handed in for credit together with the material used in the experiment. Some reward is due the student, since this is extra work. Our usual plan was to add a small percent to the credits for the report card. Pupils will work hard very cheerfully for this reward.

Some other projects may be mentioned briefly. In the spring, germination tests of seeds are always interesting. Growing seedlings, purity of seed samples, foods in seeds, may be made bases

for project work—always requiring written reports on the work, illustrated with drawings. In May and June wild flower collections are in order (but only leaf and flower). We found it wise to give opportunity to review valuable natural history books as projects in lieu of other work. We always prepared a list of suitable projects and posted them in the laboratory at the beginning of each quarter or half semester from which the pupils choose one or more. Sometimes when the topic had special value, all were asked to choose a certain project.

We found that the project work added interest and zest to work that otherwise might become dull and uninteresting. It gave a ready means for making up deficiencies, or in the case of advanced pupils (from higher grades) it gave a chance to set extra work for them to equalize their work for higher credits.

SALESMEN OF KNOWLEDGE

GLENN FRANK

The future of America is in the hands of two men—the investigator and the interpreter. We shall never lack for the administrator, the third man needed to complete this trinity of social servants. And we have an ample supply of investigators, but there is a shortage of readable and responsible interpreters, men who can effectively play mediator between specialist and layman. The practical value of every social invention or material discovery depends upon its being adequately interpreted to the masses. Science owes its effective ministry as much to the interpretative mind as to the creative mind. The knowledge of mankind is advanced by the investigator, but the investigator is not always the best interpreter of his discoveries. Rarely, in fact, do the genius for exploration and the genius for exposition meet in the same mind. Many negro mammies of the south can make a strawberry shortcake that would tempt the appetite of the gods, but they might cut sorry figures as domestic science lecturers. The interpreter stands between the layman, whose knowledge of all things is indefinite, and the investigator whose knowledge of one thing is authoritative. The investigator advances knowledge. The interpreter advances progress. History affords abundant evidence that civilization has advanced in direct ratio to the efficiency with which the thought of the thinkers has been translated into the language of the workers. Democracy of politics depends upon democracy of thought. "When the interval between intellectual classes and the practical classes is too great," says Buckle, "the former will possess no influence, the latter will reap no benefit." A dozen fields of thought are today congested with knowledge that the physical and social sciences have unearthed, and the whole tone and temper of American life can be lifted by putting this knowledge into general circulation. But where are the interpreters with the training and the willingness to think their way through this knowledge and translate it into the language of the street? I raise the recruiting trumpet for the interpreters.

THE IMAGES OF OPTICAL SYSTEMS*

By R. C. Colwell
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The mathematical relations between the conjugate foci of a lens (or mirror) and the focal length of the lens may be worked out by the ray method or by calculating the curvatures of the wave fronts. The latter method gives a direct physical picture of the process but is not usually developed in elementary textbooks because of the difficulty in distinguishing between positive and negative curvatures. All these difficulties are removed by postulating that a contracting wave front has a positive curvature; an expanding wave front, a negative curvature. This convention gives a convex lens a positive focal length.

When a plane wave front passes through a convex lens it is turned into a contracting wave front of radius f and therefore receives a positive curvature $+1/f$. A convex lens impresses his curvature upon every wave front passing through it. If an object is at a distance u from a convex lens; its wave front has a radius of curvature $-1/u$ (since it is expanding) at the moment of impingement upon the nearer face of the convex lens. In the lens, this wave front receives a positive curvature $+1/f$. If u is greater than f, the emergent wave front contracts to a conjugate focus at a distance v from the convex lens: Hence as it emerges from the lens it has a curvature $+1/v$. The sum of the three curvatures gives

$$-\frac{1}{u}+\frac{1}{f}=+\frac{1}{v} \quad \text{or} \quad \frac{1}{u}+\frac{1}{v}=\frac{1}{f}. \tag{1}$$

This is the equation for a convex lens with a real image and should be left in the first form because the full physical significance of the lens action is given in the proper order. The equation could be read as follows: an expanding wave front with radius of curvature $-1/u$ receives a positive curvature in the lens of amount $+1/f$: this produces a contracting or positive front with radius $+1/v$.

If u is less than f; the curvature of the wave front is so great that the lens cannot change it into a contracting wave front but leaves it as an expanding wave front of less curvature $-1/v$.

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Hence

$$-\frac{1}{u}+\frac{1}{f}=-\frac{1}{v} \text{ or } \frac{1}{u}-\frac{1}{v}=\frac{1}{f}. \tag{2}$$

This is the equation for virtual images in a convex lens.

A concave lens gives a curvature $-1/f$ to a plane wave front. A wave front of curvature $-1/u$ is turned into a wave front still expanding of curvature $-1/v$. Therefore

$$-\frac{1}{u}-\frac{1}{f}=-\frac{1}{v} \text{ or } \frac{1}{u}-\frac{1}{v}=-\frac{1}{f}. \tag{3}$$

A concave mirror also imparts a curvature $+1/f$ to a wave front. The impinging wave is expanding with a curvature $-1/u$; the reflected wave for a real image is contracting with curvature $+1/v$; accordingly

$$-\frac{1}{u}+\frac{1}{f}=+\frac{1}{v} \text{ or } \frac{1}{u}+\frac{1}{v}=\frac{1}{f}. \tag{4}$$

for the virtual image

$$-\frac{1}{u}+\frac{1}{f}=-\frac{1}{v} \text{ or } \frac{1}{u}-\frac{1}{v}=\frac{1}{f}. \tag{5}$$

We see at once that the concave mirror has exactly the same formula as a convex lens because both of them give a curvature $+1/f$ to the impinging wave.

The convex mirror gives a curvature $-1/f$ to a plane wave since the reflected wave is expanding. Then $-1/u$ is turned into a curvature $-1/v$. So that

$$-\frac{1}{u}-\frac{1}{f}=-\frac{1}{v} \text{ or } \frac{1}{u}-\frac{1}{v}=-\frac{1}{f}. \tag{6}$$

If a candle is placed at the center of curvature of a concave mirror, its wave front impinging on the mirror will have a curvature $-1/r$ and the reflected wave is contracting so that its curvature is $+1/r$. Then

$$-\frac{1}{r}+\frac{1}{f}=+\frac{1}{r} \text{ or } f=r/2. \tag{7}$$

A radius drawn perpendicular to any of the wave fronts mentioned above, will give the direction of the ray for that particular wave.

In finding the position of the image of a point source in any optical system, the general rule is "take any two rays from the point source, trace them through the optical system: if they actually meet again, the point in which they meet is the real image of the source: if they only seem to meet, they make a virtual image at the point of apparent intersection." Any object is considered as a series of point sources. The two rays initially emerging from the point source may be chosen arbitrarily but it is essential to choose the ones which give the simplest drawings: these may be the one which passes through the focus before reflection and the one which passes through the focus after reflection (or refraction). In the apparatus described below one ray is taken parallel to the principal axis before reflection and therefore passes through the principal focus after reflection, the other passes through the middle of the mirror (or optical center of the lens) before reflection. These ray paths may be made visible to a large group of students by means of the working models invented by Mr. Fullmer of our laboratory. The distance between the object and the mirror is variable and the different types of images are clearly revealed. In these instruments one ray is always parallel to the principal axis before reflection and the other passes to the middle of the mirror. If lenses are being discussed, one ray is parallel to the principal axis while the other passes through the optical center of the lens.

The arrangement for the concave mirror is shown in Fig. 1. A wire *APRN*, represents one of the rays from the source *A* which is reflected at *P* and so passes through the focus *F* because *AP* is parallel to the principal axis: the wire *PN* repre-

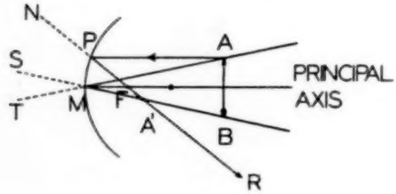

FIG I

FIG. 1. The Model of a Concave Mirror.

sents the virtual extension of *RP*. This wire is rigidly fixed to the mirror at *P* but slides through a staple at *A* on the arrow *AB*. The second ray which is reflected from the mirror at *M*

is represented by two wires *AMT* and *BMS*. *AMT* is pivoted at *A* and both wires run through staples at *M* and *B* so that the angle of incidence at *M* is always equal to the angle of reflection regardless of the position of the arrow *AB*. In the figure, *AB* is outside the focus *F* so that a real image is formed at *A'*. If, however, the arrow *AB* is moved toward the mirror, the two wires *NPR* and *BMS* will diverge more and more until when *AB* reaches the center of curvature of the mirror *A'* coincides with *B*. As the arrow is moved inward toward the focus, *A'* will pass beyond *AB* to the right; the two wires *NPR* and *SMB* will diverge less and less until *AB* reaches *F:* the wires will then be parallel, signifying that the image is at an infinite distance. When *AB* is inside *F* the dotted wires behind the mirror *ie,* *PN*, and *MS* will meet at a point giving a virtual image. Similar wires may be attached to *B* provided *AB* is supported at the middle along a wire which represents the optical axis: in this way both *A'* and *B'* may be shown.

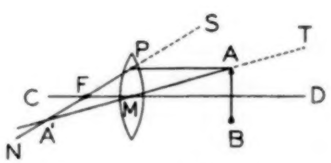

FIG 2

FIG. 2. The Model of a Convex lens.

Figure 2 shows the model of a convex lens. The wire *APFN* is rigidly fixed at *P* and passes through a staple at *A*. It represents the ray parallel to the principal axis *CD*. The wire *AMA'* is pivoted at *A* and passes through a staple at *M* the optical center of the lens. As *AB* is moved back and forth the position of *A'* may be determined. A similar system attached to *B*, will give the position of *B'*. The virtual images are shown by the intersection of *PS* with *A'AT* when *AB* is inside the focus.

In both these figures, it will be observed that the only moving parts are the arrow and the wires through the middle of the lens or mirror. Similar models may be constructed for the convex mirror and the convex lens.

When ray systems from two points are shown on a single model, they are painted different colors. The middle of a mirror must be differentiated very carefully from the center of curvature of the mirror.

SOME ANIMAL GIFTS

By W. G. Vinal

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Johnny did not join the ANIMAL CLUB. Why should he? He lived in a steam heated apartment. He couldn't own a dog and wouldn't own a cat. Old Dobbin, house rats, and bats in the garret were things of the past. Milk could even be bought in a powder. He was sure that he didn't want to join the new club. He was so sure that just before dozing off to sleep he made a foolish wish. What he probably had in mind was that if George and Jimmie and all the rest did not join the ANIMAL CLUB they would have more time to play with him. Never-the-less this is what he wished: "That animals and anything that had to do with animals did not exist." For one day Johnny got his wish.

During the night Johnny was very cold. He did not know that the wool had disappeared from his blanket nor that the goose-down pillow was nothing but an empty ticking. He was surprised that the plastering had fallen off because there were no hairs to hold it together. Even the photographs of his father and mother that had always stood on the dresser had faded away because gelatine is necessary for photographic plates. The woolen rugs had gone but he jumped up with a smile. He was glad that he would not have to use his bone-handled, pig-bristled toothbrush. As for soap he had always known that that was a nuisance. When he couldn't find his comb or hairbrush he was already to say that they were useless.

His new suit was "no where to be found." With a nonchalant air he appeared in the kitchen in his cotton pajamas, with uncombed hair, and a silly smile. His poor mother was bare-footed and was making an attempt to get breakfast without animal products. His father was hunting for his leather belt and buckskin hunting jacket and was fussing because someone had stolen his "sheep skin" that he had worked four long years in college to obtain.

Johnny appeared for breakfast. There was no lard to fry the potatoes and no ham, or eggs, or milk. He bravely ate his boiled potato, had corn flakes without milk, bread without butter (not even oleo), and a glass of water. His mother's bone-handled bread knife was no more and he was given a clothes pin to use in place of the bone napkin ring which his uncle had sent for his birthday.

By the end of breakfast Johnny was very sorry that he had made such a wish. He thought to himself, if I can get out and play I will forget about it. His old felt hat and gloves were gone but he finally put on a straw hat, rubber boots and his old macintosh. The lining was all gone and both the buckle and buttons were missing. A piece of string was pressed into service. Of course he looked funnybut he must play. As it was a cold day he thought that he would kick the "pig skin." Lo and behold then there was no "pigskin." Then he looked for his baseball. It was then that he recalled that ball players sometimes speak of "hitting the horsehide." Then he found the string of his tennis racket gone and along with it his balloon, dice, and billiard balls. Even he knew that he couldn't go fishing or horseback riding, or watch the polo game. What could he do?

Like many a boy that has nothing to do he thought of the "movies." Now he could surely forget his troubles. He noticed that the gold letters on the "movie" sign had lost their lustre because there was no gold beater's skin to beat the thin sheets of gold. He was so glad to get away from "the no animal idea" that he did not see that the leather-cushioned furniture had turned to hardwood seats. The manager announced that there would be no film as the gelatine had fallen away. He said that for some mysterious reason the drum heads had vanished and the strings were missing on the cello and violin. He planned to substitute the phonograph but the gelatine had left the records. What a dilemma. The only music was to come from the wind instruments. Even they were curved like the horns of an animal and for that reason seemed to mock Johnny.

He could stand the "movie" entertainment no longer and thought that he would go to the library and read. The library was up in arms. The leather binding had vanished, the glue had permitted the books to fall apart, and all the prints had disappeared in thin vapor. The three ply wood was falling apart and parts of chairs and tables were lying about the room. Johnny felt sick.

He rushed to the drug store. The druggist knew that something terrible had happened. He knew that Johnny needed something but he had no glycerine, or pepsin, or cod-liver oil. He was all out of thyroid extract. Johnny must have an infectious disease but there was no gelatine to make a culture. He could only recommend that Johnny go home and go to bed. And do you know that Johnny did not mind a bit that he did

not have mutton tallow candles for a light. He hopped into bed and declared that if animals give us all those things "I am going to join the ANIMAL CLUB tomorrow."

Johnny did join the ANIMAL CLUB. He learned that he also is an animal and thousands of other surprising things. But the most important thing of all was that he resolved not to make any more foolish wishes.

A BRIEF NOTE ON HORNER'S METHOD

By CECIL B. READ, *University of Wichita, Wichita, Kansas*

The application of Horner's method to obtain approximate values of the irrational roots of numerical equations is more or less standardized. Having located a positive root between two consecutive integers, we obtain a new equation whose roots are less than those of the given equation by the smaller of these two integers. This equation will have a root between 0 and 1; which we locate between successive tenths, and decrease the roots by the smaller of these tenths. We now have an equation with a root between 0 and 0.1, which we locate between successive hundredths. The process is continued until the desired degree of accuracy is obtained.

Personal contact with the late Dean Fine of Princeton has made me feel very favorable toward the suggestion made in his College Algebra: We may avoid the troublesome decimals which occur in the transformations after the first by multiplying the roots of each transformed equation by ten before making the next transformation. This may be done by affixing one zero to the second coefficient of the equation in question, two zeros to its third coefficient, and so on. I feel, however, that this is largely a matter of personal choice with the teacher.

It is with the finding of negative roots that this note is concerned. Practically without exception, every text treating the subject says in effect that the method of finding a negative root is to consider the corresponding positive root of $f(-x)=0$. There is nothing compulsory about this method, nor, in my opinion, is there any simplification. If a root is located between two consecutive negative integers, we may proceed exactly as in the case where the roots is positive. We obtain a new equation whose roots are less than those of the given equation by the numerically smaller of these two integers. This equation will have a root between 0 and -1; which we locate between successive tenths, and decrease the roots by the numerically smaller of these tenths (in effect, we increase by this amount). As with the positive root, the process is continued until the desired degree of accuracy is obtained. The only change in the case of a negative root is the use of a negative number in the synthetic division.

Experience with high school seniors and college freshmen leads me to believe that this process seems more natural to the student. Certainly I can state that I have found the last process practically eliminates the question, "What did you say that I should do to find the negative roots?" To me the surprising feature is the almost universal agreement among text book writers, when the alternative procedure involves no more difficult operations.

THE MATHEMATICS OF THE ORIENT*

By Louis C. Karpinski
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For an American who has for some 30 years lectured on the importance of the Mathematics of the Orient before American audiences, it is an inspiring moment to stand before so distinguished an audience in Istanbul at the famous Turkish University of Stamboul. Here at the Bosphorus and at your Straits of the Dardanelles the civilization of Asia and Europe made contact with each other over many centuries. Egypt and Babylon and Sumeria and India and possibly even China passed at different times through these portals. Not only the spices, the fine silks, ivory and metal ware and other beautiful objects of commerce passed through these avenues but also the ideas of the Orient came along in the same caravans with their goods. With the art of the Orient went also the arts and sciences and the learning.

In mathematics practically nothing was known of the Egyptian and Babylonian-Sumerian developments until sixty years ago. Even until about five years ago we were largely dependent for our information about Egyptian mathematics upon one single great document, the Papyrus Rhind of the British Museum, and for Babylon upon a few scattered Babylonian tablets. The fragmentary and accidental character of this information is obvious. Today, however, notable additions to our knowledge of the mathematics of the Nile and the Tigris and Euphrates are available. These new documents reveal unexpected achievements in ancient Babylon and Egypt. The new material may be said to revolutionize our ideas concerning the mathematical attainments in both Egypt and Babylon.

Naturally, too, if our knowledge of the mathematics of these ancient civilizations is incomplete, evidenced by the new discoveries, so is also our knowledge of other phases of their activities, intellect and physical. The discovery of the fluted column in Egypt, long ascribed to Greek art, and the architectural discoveries in Mesipotamia indicate that the early history of art and architecture may have to be rewritten as well as the story of the development of mathematics.

The whole question of the dependence of the civilizations of

* Address given in Istanbul, Turkey, in the University of Stamboul, December, 1933

Asia Minor and North-eastern Africa upon Hindu and Chinese influences may be entirely changed within the next decade since the Babylonian-Sumerian mathematical ideas now are seen to be related to the Hindu developments, possibly dependent upon them.

Recently Dr. Otto Neugebauer of Göttingen has published a cubic equation, $x^3+x^2=252$, which was formulated in Babylon about 4000 years ago. The tremendous significance of this discovery consists to a large measure in the fact that this is one of the oldest mathematical documents known; the preceding development of mathematical ideas which made the formulation of such advanced problems possible, that is entirely unknown.

The Babylonians and Sumerians solved a whole series of quadratic equations arising out of geometrical problems. These problems, also published by Dr. Neugebauer, connect with recent and older discoveries of Egyptian mathematics to form a logical sequence with fundamental Greek developments.

One Babylonian problem reads about as follows: Given the area of a rectangle together with the difference of its sides as 3:3 or 183, being written in the sexagesimal system, and given the sum of the sides as 27, what is each of the sides? In modern algebraic symbolism:

$$\begin{array}{rl} xy+x-y &= 183 \\ x+y &= 27 \\ \hline 27x-x^2+2x-27 &= 183 \\ x^2+210 &= 29x \end{array}$$

This equation gives the sides of the rectangle as $x=15$ and $y=12$ (area 180 and difference of the sides 3, whence 183), and the sum of the sides 27. There is a second solution $x=14$, $y=13$, and the ancient cuneiform tablet preserved in the Louvre in Paris gives both solutions.

There is a group of such problems involving in each case the area of a quadrilateral together with some linear function of the sides, such as one-half of one side plus one-third of the other side. In each problem the sum of the sides is given. As indicated above the solution of the problem involves that of a quadratic equation. Here in several of the problems complicated square roots result, often requiring approximate irrational answers, which are given.

In the second and the sixth Book of Euclid's Elements, the

theory involved in these Babylonian problems is fundamental. Entirely similar problems are given by Euclid in his book, "The Data." Herein Euclid states an analogous problem concerning rectangles as follows: "Given the area of a rectangle and also given the sum of its sides, then each of the sides will be known."

Again, "Given the area of a rectangle and given the difference of its sides then each of the sides, will be known."

Algebraically,

$$\begin{aligned} xy &= a^2 \\ x+y &= b \end{aligned} \qquad\qquad \begin{aligned} xy &= a^2 \\ x-y &= b \end{aligned}$$

Euclid gives a whole series of further problems on this theme.

In an Egyptian papyrus found at Kahun there is the problem to divide a square area of 100 square ells into two squares whose sides have to each other the ratio 3:4. This leads to two squares whose sides are 6 and 8, respectively. Note that this gives a rectangle whose sides have to each other the ratio 3:4 and whose diagonal is 10. In other words we have here a 6, 8, 10 right triangle or the 3, 4, 5 right triangle by which quite certainly the ancient Egyptians constructed right angles, in building, just as carpenters do today practically all over the world. In the recently published Moscow papyrus other problems on rectangles appear so that no doubt can now exist concerning the absolutely intimate connection between these algebraical developments of the Egyptians and the Babylonians with each other and most particularly and evidently with the Greek developments mentioned which occur in Euclid's Data and in the second and sixth Book of Elements.

The glory of the development of an almost perfect system of logical geometry is not in any wise dimmed by the fact that Egyptian and Babylonian progress in thought may have contributed some ideas. In point of fact Greek science becomes with this connection a more integral part of the history of man, of the progress of reason and intelligence in the world.

The discovery that the Babylonian-Sumerian-Assyrian civilizations utilized the Pythagorean theorem to compute chords in a circle corresponding to various angles, is another profoundly significant recent discovery. This establishes at once another connection between the Greek astronomy and trigonometry and the oriental. The rapid progress much later of trigonometric ideas in the Islamic lands becomes more easily understood.

Even in so advanced a field as summation of series the ancient Babylonians made real progress.

The Greek mathematical developments are known to us through the fortunate preservation of complete works, such as those of Euclid, Archimedes, Diophantus, Apollonius, Aristarchus and Pappus. We will assume that this story is too well known to need further discussion.

In order to understand the immense contribution of Islam to the progress of mathematical science it is necessary to indicate briefly the contributions of the Hindus whose intellectual activity extends doubtless over several thousand years. However, undoubtedly crucial developments in Hindu mathematics followed chronologically upon the Greek developments.

In arithmetic the Hindus contributed the system of arithmetic with the zero which we use, whether it is the Arabic point (·) zero, or our circle (0) zero. This system brought computation within the range of people of ordinary ability. In algebra the Hindus made great progress in symbolism for several unknowns, in symbolism for positive and negative quantities, and in extending the algebraic problem material. In trigonometry the Hindus contributed the sine and cosine functions and the tangent function (shadow) making a simplified trigonometry possible.

The most noteworthy Mohammedan contribution to the progress of mathematical science lies first in the union of the scientific advances of the Greeks with the fundamental achievements of the Hindus in fine textbooks useful for instruction purposes. Islam placed alongside Euclid's marvelous Elementary Geometry other fine textbooks in arithmetic and Algebra and Trigonometry. The Persians and the Turks and the Arabs and the Egyptians, all using Arabic, appreciated and preserved the mathematics of Greece and of India. Had the Arabic speaking people done nothing more than to preserve, as they did, Greek science they would have been entitled to the profound gratitude of later civilizations, indebted to them for that material. However, the Arab added textbooks embodying a combination of Hindu ideas with the Greek logical science.

Further than this the science of plane trigonometry was the creation about 1274 A.D. of Nasir-ad-Din at-Tusi, a Turkish citizen, I believe. The importance of the trigonometry in the development of European science has never, it seems to me, been adequately stressed. The more or less modern applications of

calculus to problems in engineering rest largely upon the sine and cosine functions, the use of the Hindu half-chord instead of the full chord of the Greek trigonometry.

You are all in this part of the world, more or less familiar with revolutions and with rotations. Even in the automobile you have constantly before you revolutions whether inside in the machinery or outside in the wheels. The sine function increases from 0 to 1 as the angle increases from 0 to 90 degrees; when the angle increases from 90 degrees to 180 degrees, the sine decreases from 1 to 0 and then from 0 to -1 (negative 1) as the angle increases to 270 degrees. Finally when the angle marches from 270 degrees to 360 degrees, completing one revolution, the sine increases from -1, negative one, up to 0 and then as the angle becomes greater than one revolution, the sine function repeats from 0 to 1 back to 0 to -1 and then up to 0 again, over and over again. Of course, this is the wave motion character even of our breath, of the beating of our heart, of the pulse; this is the repeating motion over and over again, of machinery; this is involved in "quantity production"; this is essentially what made Henry Ford a rich man, by producing millions of "flivers." When you try to analyze this type of motion mathematically you must use the sine and cosine function.

The mathematicians of India and Asia Minor, assisted by certain ideas borrowed from the Greeks, created a trigonometry which could be utilized with the algebraic analytic geometry and calculus to interpret physical phenomena mathematically. The mathematical interpretation of physical phenomena was in large measure responsible for the creation of the modern machine age. The apparently artificial symbols of mathematics, notably the cyclically repeating trigonometric functions, these being properly utilized by physicists made possible the mechanical and electrical machinery of the age in which we live.

The contribution of Islam to Europe in mathematical science was transmitted through the activity of translators from the Arabic into Latin and Hebrew. My friend Dr. George Sarton has shown this clearly in his monumental volumes on the history of science. Further than this some of this material was translated very early into French, a fact also somewhat neglected but of fundamental importance for the progress of science in Europe.

The immense amount of material placed in the hands of the Europeans by Islam not only in mathematics, but in mechanics,

in medicine, in astronomy, in physics and in other fields, undoubtedly led, as Dr. Sarton has indicated, to the creation of the European universities.

The Algebra of Al-Khowarizmi (825 A.D.) inspired in Italy the study of the cubic and biquadratic equations. In this field the poet-mathematician Omar al-Khayyami (1100 A.D.) showed that the Arabic speaking mathematicians had reduced the trisection of an angle and the construction of the regular polygons of seven and of nine sides to cubic algebraic equations. Abu Kamil Shoja ben Aslam, the Egyptian, about 925 A.D. reduced the problem of the pentagon to a fourth degree equation, soluable by quadratic methods. These amazing developments, connecting again the geometry and the algebra, constitute also a step towards analytic geometry.

When the great French genius Vieta attempted to place about 1591 A.D. the Italian contributions in Algebra in more systematic form the result was the creation of algebraic symbolism, one of the most fundamental steps in the progress of mathematical science. I believe that I have indicated above how this step was dependent upon Italians, upon Hebrew and Latin translations of Arabic documents, upon the Arabic speaking world and upon India, upon Greek science, and upon Babylonian-Sumerian and Egyptian mathematics.

The algebraic symbolism of Vieta in turn made possible the analytic geometry of Descartes, 1637 A.D., sometimes termed the beginning of modern mathematics. Isaac Newton and his differential and integral calculus of fluxions, and equally Leibniz and his calculus of derivatives and integrals would not have been possible without the algebraic symbolism of Vieta.

In very truth the calculus made possible the modern world. But the calculus itself, is only the culmination of the thinking of devotees of the mathematical art, from the beginning possibly in some distant central part of Asia, through the various civilizations which I have mentioned where there was cultivation of beauty and mathematics. In the achievement of the modern world such as it is thousands and tens of thousands of thinkers, in every part of the world through all the ages known to history, have had their immortal part. When you students are given arithmetic, algebra, geometry, trigonometry and the higher mathematics, you are indeed made "the heirs of all the ages past."

THE MISSION OF THE BIOLOGY TEACHER

By H. E. Stork

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The teacher who looks on her position as a job with a certain amount of work required for which she draws a salary to make another deposit on the new fur coat will probably not be very happy. The teacher who goes with the spirit of a missionary, aware of boundless opportunity for enriching the lives of her charges and eager to seize upon such opportunity will never be bored with her work.

The mission on which the biology teacher is sent to a high school is one of emancipation. If she has a fine insight into the meaning of scientific method, is possessed with scientific habits of mind, and is thinking, then she can go a long ways toward freeing a community from the bondage of the unscientific lore of the past. Hendrik van Loon has said: "A drop of science is often enough to disinfect a whole barrel of ignorance and superstition."

The race has inherited a large stock of beliefs from the past racial experience. Perhaps nine-tenths of these are "heirloom rubbish" and the best that can be done is to develop scientific habits of thought in the individual mind so as to enable it to chuck out the worthless stuff. It is, however, the other tenth that makes us proceed cautiously in this business, because that is the priceless treasure that has been painfully acquired in the past and that must not be lost to the race. It is astonishing how bounden people are to beliefs and opinions of others, how few do any first-hand thinking for themselves, or perhaps we might say how few think at all. Second-hand opinions rule the world. Nearly everyone has learned to depend on teachers, books, editorials, etc., for his second-hand opinions. This means a dependence on "authority," and the history of science teaches that the great enemy of progress of science and indeed of civilization in the past has been authority. The whole spirit of scientific study is one constant protest against second-hand opinions. It is for this reason that we are loath to class a course in textbook science as science at all. When the textbook is set up as an authority, inculcation of the scientific method of thinking stops.

The mission of the biology teacher is not alone and not chiefly the putting across the facts of plant and animal life. She must do that but that is only a beginning, a means toward an end.

The first and foremost mission that she must fulfill is to carry the scientific spirit and make it a part of the thought habits of the pupils. What is the scientific spirit? Like religion, it is better experienced than defined. It implies instinctively, appealing only to the authority of direct observation and none other. It implies an unbiased, unprejudiced observation; maintaining the spirit of inquiry constantly; doubting all things reasonably until verified; knowing what constitutes proof; suspending judgment until all the evidence is turned in. The lack of this scientific spirit in the thinking habits of any community makes possible the following of demagogues and the persistence of rotten politics, the flourishing of all sorts of charlatanism, the successful dissemination of idle gossip and slander, the creation of misery by incorrect habits of living, intolerance of neighbors, interchurch warfare, loss of money in unsound investment, and, I believe we are correct in saying, most crime.

There has been a strong tendency in recent years to link the teaching of biology with human welfare. I have no doubt that the majority of teachers are so shortsighted as to think that the only way they can help the welfare of the community is to teach habits of health, hygiene, and sanitation and to give some vocational guidance. This is valuable and important. It is not of chief importance. More important is the leavening of the whole loaf that comes from teaching right habits of scientific thought as we have indicated in the preceding paragraph. Some go to Rome without seeing St. Peter's. And some writers give the aims of the work in high school biology and do not emphasize or else leave out entirely this one of first magnitude.

Perhaps the greatest fallacy from which we suffer in the whole field of education is the confusion we entertain between the imparting of information and the development of habits of thinking. That this fallacy is widely entertained is evident from the whole literature on education; it is evident from the methods employed in measuring the results of education. We know in an academic way that the storage idea of education is not quite right, we know that education is not the pouring of information into the pupil through the funnel of devices and methods, but we still muddle along and act as if we thought it were. It is precisely here that our wide acceptance of general science is to be explained. Information is the thing, and general science offers the best information, and so we teach general science, entirely oblivious to the fact that it is easier to inculcate right habits of

scientific thinking by teaching a small field of subject matter and teaching it well than by trying to cover not only a lot of ground but in fact the whole universe from the movement of the heavenly bodies to the mechanical principles underlying the rotary sewing machine.

Coulter remarks that, "Whole systems of beliefs and lines of conduct have been constructed upon a basis of claimed fact which a child in the grades, trained in nature study, could he understand the terminology, would reject without hesitation. An injection of such children in large numbers into any metropolitan community would work a revolution." With the large percentage of the future population going through the high school now, we have a chance to work a revolution in the matter of independence in observation and inference. I suspect we are doing it only poorly. We are teaching a little parrotting of what the biology book says, going through a few experiments which usually do not come out right, we explain how they should have come out, we are giving the pupils some busy work in the way of drawing plant and animal structures so that we can have a neat notebook to grade at the end of the month. All in all, we wind up by thinking that we have taught the subject matter as well as it was taught the year before, entirely oblivious to the fact that while we may have taught the subject matter, we have not taught the pupil at all. He has not undergone any modification in his thinking; except for a few fragments of fact which he will soon remember only vaguely, he is the same as he was when we took him over for instruction. That's why biology has not come into its own as a high school subject. It has not had a fair chance.

With respect to unscientific habits of thought, let us use an illustration. In a community in Southern Indiana that I know well from boyhood days, there was a great deal of stock taken in the common woodchuck or groundhog. Candelmas was his day; it was rechristened "groundhog day." The legend had him come out for the first time after the dead of winter on this day. If the sun shone and he saw his shadow, back he went for another six weeks, for there would certainly follow six weeks of such weather as no groundhog would enjoy. As an old folk legend of the early days this was interesting and worthy of preserving. But in that community plans were made and one's life was ordered for the next six weeks in accordance with the prognostication of this animal on that particular day. One dared not

venture a reasonable doubt about the accuracy of the creature's prediction. I suggested once to a man that perhaps there wasn't anything in it. He replied with an air of finality that there were people who presumed to doubt it; but as for him he knew. He had proved it. Some years ago he had been going through a clearing on the second of February, when a woodchuck appeared from under a stump. The creature looked about a bit, saw that the sun was shining, and turned back into his hole. And, sure enough, they had some "pretty rough weather" the next six weeks. This was the proof that he himself had achieved, and while some presumed to be too wise to believe in it, he could stand aloof of them because he really knew. Such is the false logic, such is the inducing of a general principle from a single observation, such is the ignorance of what constitutes proof that we find on every hand.

I dare say that the young generation going out from the high school of that community today have a more rational way of regarding meteorological prognostication. Dr. Hick's calendar that gave detailed analysis of weather for the three hundred sixty-five days of the year perhaps no longer holds a place beside the family Bible in every home as was true yet even thirty years ago. There has been a slow leavening of science instruction that, though poorly given, yet achieved some little success in showing what constitutes proof and that reasonable doubt might at least be tolerated.

Such then is the chief mission of the high school biology teacher, as we see it. There are many secondary aims and objects. They are more readily perceived and more easily understood. Initiation of the young minds into the secrets of protoplasmic life with all the thrills that their discovery holds; the opening of new windows and extending and widening of vistas so as to make life richer and more interesting; unfolding the secrets of better and more wholesome physical living; these and others the average syllabus and text points out and we need not emphasize them here.

Indium, uranium, cerium, tantalum and neodymium, chemical elements so rare that they are mere names to most of us, have possible uses in the glass industry, Dr. William Murray of the Johns Hopkins University indicated in a report to the American Chemical Society. All these elements color glass yellow. Dr. Murray has himself produced some beautiful yellow-tinted glass, using indium sesqui-oxide.

ORGANIZATION OF MATERIALS FOR TEACHING GEOGRAPHY IN THE HIGH SCHOOL*

By Alice Foster
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Organization implies specialization. For purposes of the present discussion it means the arrangement of materials to adapt them for the performance of a specific function. In demanding that materials be organized, it is assumed that the educational function can be separated into several parts and a particular body of material be held responsible for each. In this discussion, it is proposed to recall a half dozen familiar principles regarding the organization of material for teaching, apply them to commercial geography at the high-school level, and illustrate their application to a particular body of material. The following list will be referred to as needed.

PRINCIPLES

I. In order to organize material effectively, the organizer must have in mind a specific function to be performed.

II. The need for organization of material implies that the specific function is composed of several processes or duties which can be apportioned to different bodies of material.

III. Effective forms of organization provide for emphasis on those facts and principles which have the highest permanent value.

IV. In order to set up an effective organization, the organizer must know the material well enough to be sure of his own bearings therein and must understand the educational function which it is expected to perform.

V. The most effective types of organization provide opportunity for the student to discover essential facts or principles through his own activities.

VI. Successful types of organization provide opportunity for the young investigator to announce and describe or explain his discovery.

The application of Principles I and II demands that the course assume responsibility for performing a definite educational function capable of being split up into distinct processes,

* Read before the Geography section of the Central Association of Science and Mathematics Teachers, Dec. 1, 1933.

each of which may be undertaken by an individual unit or lesson. A successful act of organization, therefore, demands that the organizer have a comprehensive view of the course as regards its place in education and a definite concept of how the particular unit fits into the general plan.

In order to apply Principles I and II to commercial geography at the high-school level, it is necessary to inquire into the function which such a course is expected to perform. Since a definite aim of secondary education is to help the adolescent find his place in the mature world, it is logical that the responsibility resting on commercial geography should be that of orientation in the world of commerce and industry. Such orientation develops in the mind of the individual an ability to see his own business in its world setting, and thus it contributes to a satisfying individual performance. This insight involves familiarity with the big commodity movements which stand out as trunk lines in the bewildering maze of modern commerce, a recognition of orderliness in the location and trend of these dominant lines, and an appreciation of the forces which, in regions of production and regions of consumption, tie commodity movements to the earth. It entails an acquaintance with the natural and cultural conditions which empower a few regions to hold rank as major foci in the world pattern. It embraces a knowledge of the great highways of trade, supported by a comprehension of the attractions which draw huge volumes of traffic to these routes. Such is the structure which commercial geography endeavors to build.[1] A structure of such complexity must needs be analyzed into its component parts and material suitable for building each of the parts must be assembled from the available sources. Of the established bases for analysis, the one to be discussed here conceives world trade in individual commodities as elements in world pattern, each commodity trade pattern forming a layer, so to speak. Complexity does not disappear with this process of analysis, for trade in an individual commodity shows a complex pattern. In nearly every case, at least a half dozen regions are concerned, and the tangle of trade lines is confusing to the uninitiated.

Orientation being the motive, one who plans a course will apply Principle III in organizing material for individual units, and also in selecting the units to be included in the course. In

[1] The theme of this paragraph is developed more fully in *The Thirty-Second Yearbook of the National Society for the Study of Education*, pages 288–290.

each commodity trade pattern one line stands out so prominently as to dominate the design, and in an effective scheme of organization, it is singled out for emphasis, while other features are noted in their relation to the dominant line. The contribution of the unit to orientation involves a recognition that the location and trend of this dominant line depend upon the forces which at source and destination tie it to the earth. At source it is held in place by certain tyrannies of nature that allow the production of the commodity in some regions but impose prohibitive difficulties upon the production of the same commodity elsewhere. At destination it is tied down by the geography of consumption, which determines what regions can afford to purchase the commodity. Thus, world trade in a commodity has a regional phase as well as a highway phase, since commodities are produced in regions and consumed in regions. Similarly, when commercial geography is organized with orientation as its educational aim, each commodity trade pattern selected as the basis for a unit performs two related tasks belonging to the general function of commercial geography. It builds up a concept of an important element in the world's commercial pattern, and in addition it serves as a convenient key to unlock the geography of a region.

The force of the statements made above can be recognized most readily when applied to a particular branch of trade, and for this purpose world trade in raw wool has been selected. The areal pattern of this trade is suggested by the map appearing in the *U. S. Department of Agriculture Yearbook* for 1923, page 291.[2] The dominant line in the pattern is the one connecting Australia and Western Europe, the major source and the principal destination. A study of this commercial line is capable of bringing out the essential features of world trade in raw wool, since the shipments from Australia to Western Europe constitute the largest single movement of raw wool in the world, and since principles having wide application are involved. It forms a convenient instrument for investigating the geography of Australia, since raw wool is Australia's leading export, since wool production spreads over huge areas of Australian land, and since numerous inter-relations with other industries point out avenues to as comprehensive a regional study as may be deemed expedient. The discovery of the dominant line in the pattern

[2] This map is reproduced in Colby and Foster's *Economic Geography for Secondary Schools*, page 256.

and of its utility as an instrument for geographic interpretation constitutes the first stage in the organization of a unit on the world's raw-wool trade.

The second stage in organizing a unit on the subject under discussion consists in discovering how facts can be aligned to make them perform the orienting function for which the unit is responsible. The orienting concept which the unit aims to build up has as its framework a visual image of the trade pattern, and the big movement of wool from Australia to Western Europe forms the backbone of the skeleton. Memory of facts is involved in erecting this structure, but facts, if skilfully mobilized, get themselves reasoned about and thereby dig themselves deep into the mental tissues. Thus, the visual image of the areal pattern of the wool trade is deepened through thinking critically about the regional circumstances which make a wool deficit in Western Europe reasonable, about the reasonableness of devoting to wool production the vast Australian plains where remoteness and water scarcity allow only a narrow margin of choice in methods of making a living, and about the characteristics which distinguish the Suez Route from other ocean highways connecting Australia with Western Europe. Recognition of the principal competing wool movements and the principal competing regions lends balance to the image of pattern and maintains the world scope of the investigation. Comparisons and contrasts disclose reasonableness in the secondary rank of these competing movements and regions, thus making them contribute to orientation instead of leading to confusion.

The organization of material to enable it to perform an orienting function demands that the organizer be thoroughly acquainted with the material itself (Principle IV). He must have command of facts, processes, and even incidents which throw a light of reasonableness on the main phenomena of the trade. Before he can set up an effective organization, the facts must have aligned themselves in his own mind so that each fact has its place and meaning with reference to other facts and with reference to the big concept which the unit aims to build. Such an arrangement of facts concerning the wool trade is shown in *The Thirty-Second Yearbook of the National Society for the Study of Education*, pages 292–293. Two sets of facts are outlined in parallel columns. The first column carries elements of the trade pattern which have permanent value for orientation, while the outline in the second column lists facts which point to reasona-

bleness in the elements of areal pattern named in the corresponding space of Column I. The outline devotes a considerable amount of space to the areal pattern of wool production in

To be Discovered	Materials through Which Discoveries May Be Made	Activities Capable of Leading to Discoveries
Rank of Western Europe as Destination for Raw-Wool Shipments	Destination of Australian Wool Exports—Average for 5-year period ending with 1930–31.[3] Britain 117,545 tons France 84,486 Japan 53,467 Germany 51,745 Belgium 43,651 Italy 17,848 United States 13,036	Map showing destination of Australian raw-wool exports for 5-year period ending with 1930–31. *Directions:* On an outline map of the world, show the destination of Australian export wool by drawing straight lines from Australia to each importing country named in the column opposite. Let each line stand for 20,000 tons, but if there is a remainder of 10,000 tons or more, add another line. If the remainder is less than 10,000 tons, disregard it.
Rank of Australia as Source of Export Wool	Sources of British imports of raw wool—Average for 5-year period 1927–1931.[4] Argentina 32,721 tons Australia 127,747 Chile 12,429 India 23,436 New Zealand 93,177 Union of South Africa, and Southwestern Africa 77,800 Uruguay 12,389	Map showing sources of British wool imports for 5-year period 1927–1931. *Directions:* On an outline map of the world, show the principal sources of British wool imports by drawing straight lines from England to each exporting country named in the list opposite. Use the same scale as that given above.
Quality of Australian Export Wool	British Wool Imports Average 1927–1931. Source — Tons — Value—£ Australia — 127,747 — 17,410,636 All other countries — 276,817 — 33,634,618	Mathematical computation to answer the following question: How does Australian wool compare in quality with that imported into Britain from other countries?

FIG. 1. Suggestions for organization of materials to aid students in discovering salient facts regarding the areal pattern of world trade in raw wool.

[3] List includes all countries whose average imports of Australian wool exceeded 10,000 tons. Data from *Official Yearbook of Australia*, 1932.

[4] List includes all countries whose average exports of wool to Britain exceeded 10,000 tons. Data from *Annual Statement of the Trade of the United States Kingdom*, 1931.

Australia and relatively little to the areal pattern of wool consumption in Western Europe. This is because the wool trade has been selected as a key to the geography of Australia and confusion would result from trying to interpret two regions at once. If previous units have revealed the commercial magnetism of Western Europe, that understanding will be drawn upon here. Otherwise, later units will gather many fragmental understandings and weave them into a recognition of the function of Western Europe in the Commerical World.

The arrangement of materials to guide students toward the discovery of significant facts or principles constitutes a vital part of organization for teaching (Principle V). This task requires that the organizer decide which facts and principles are significant. He asks himself, 'Just what do I want the students to carry away from their study of this unit as a permanent mental possession?' He will not expect too much if he is wise, knowing that the attempt to teach everything about a subject results in giving the students confused notions valueless for orientation. The facts or principles selected as of major importance then become subjects for student investigations. For the unit considered in the present discussion, it is clear that a visual image of the trade pattern represents a concept having high value for orientation, and that the movement of wool from Australia to Western Europe is the strongest orienting feature of the trade pattern. This phenomenon, involving both location and quantity, lends itself to development through some combination of map work and the handling of statistics. Figure 1 gives data suitable for emphasizing the source and destination of the major wool movement and suggests one type of activity whereby the wished-for discovery may be made.

Statistics lose their forbidding aspect under a skilful organization which uses them as aids in making discoveries. Certain statistical facts render their most effective educational service when thrown into the form of "disconcerting data." For example, there is apparent discrepancy between the supremacy of Western Europe as a wool-importing region and the fact that Europe contains nearly twice as many sheep as Australia.[5] The discovery of reasonableness in this situation comes through a consideration of population densities (Fig. 2) and of climate in their bearing on the wool requirements of the countries con-

[5] *Commerce Yearbook*, 1932, Vol. II, pp. 686, 689–690.

cerned. There is potential surprise also in the fact that Britain, the leading market for Australian wool, has more than 270 sheep per square mile, while the number per square mile in Australia falls below 40. This condition calls for a discussion of the carrying power of pastures in contrasted types of climate and further emphasizes the contrast in population density. Queries capable of rendering educational service may arise also from the discovery that Australia's 110 million sheep produce more wool than Europe's 216 million.[6] These queries invite inquiry into the choice of breeds according to whether the owner is interested chiefly in the wool trade or the mutton trade. The facts brought

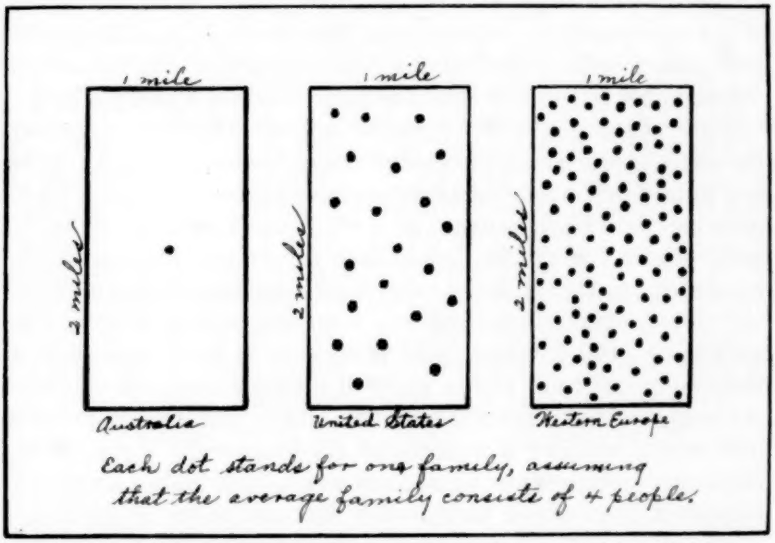

FIG. 2. Scheme for emphasizing contrasts in population density.

out by such an investigation illustrate contrasts between an industry operating in a commercially remote region and a similar industry carried on near a great market. They also reveal the triumph of Australian ranchers in developing types of sheep which average twice as much wool per head as do the sheep of Europe. They point out varying degrees of remoteness in Australia, since dual-purpose sheep are favored by ranchers near the ports with packing plants to prepare mutton for the frozen-meat trade, while at remote interior stations the sheep industry has received no benefit from the development of refrigeration.

In studying the geography of Australia through the wool

[6] *Commerce Yearbook*, 1932, Vol. II, p. 685.

trade, two regional concepts of orienting value are to be sought —the areal spread of wool production, and the reasonableness of this areal pattern. In seeking to discover the reasonableness of distribution, the areal pattern of wool production becomes an effective key to the differentiation of areas in Australia as regards their utility for making a living. Search for the conditions which fix the areal limits for wool production reveals two types of frontiers, both of which are represented along a line from Sydney to the interior of the continent. The maximum density of sheep is found in a belt roughly parallel to the southeastern coast. There grazing and crop-growing overlap, and much of the cultivated land is planted to forage crops. The seaward border of the sheep-raising country runs through an area having a dependable rainfall sufficient for forest growth. This belt offers considerable latitude of choice as to methods of making a living, and the absence of sheep from the coastal strip does not mean the absence of man. Between the sheep-raising area and the sea is a humid belt where small farms devoted to dairying or fruit-growing yield high returns per acre. Several hundred miles inland, where the grazing lands face the empty interior of the continent, scattered flocks roam over vast fenced pastures, for the thirsty land can furnish but a meager supply of feed. The growth of grass varies greatly from year to year, according to the amount of rain, and in years of drought many sheep die of starvation. This is a transition belt where man has found only one way of making a living, and the frontier of sheep-raising coincides with the frontier of settlement. Beyond lies a vast uninhabited area where no industry has succeeded in gaining a foothold. Since the amount and regularity of rainfall constitute the most significant difference between the inhabited and unoccupied areas of Australia, an effective organization will provide for developing a concrete idea of an arid climate. Essential elements in the concept of scanty rainfall are the amount of precipitation, its seasonal distribution, and its dependability. Figure 3 gives data suitable for building up such a concept by constructing a series of rainfall graphs and then discussing them to point out and emphasize critical contrasts. For purposes of comparison, data are given for one station in the United States. Obviously, the best station for this purpose would be one located near the home of the students.[7]

[7] Data for a large number of stations in the United States are given in *Bulletin W*, published by the U. S. Weather Bureau.

Adequate instructions for student investigators include three essential parts. First, it is important that students understand at the outset just what to look for. Guidance through a series of steps in reasoning is much more effective if students know the purpose of the reasoning. Many carefully directed exercises fall short of their aim because students are led through the various steps without knowing to what goal the steps lead. Second, spe-

	Average Amount	Dependability
Annual	A. Average annual rainfall for lettered stations shown in Figure 4.[8] (Data for graph with vertical bars forming a rainfall cross section of Australia. Order of bars should agree with order of stations on map.)	C. Rainfall for each year, 1915–1924, in inches.[9]
Monthly	B. Average monthly rainfall, in inches.[9]	D. Monthly rainfall (in inches) for the year in the ten-year period 1915–1924 when the total amount was nearest to the annual average.[9]

A. (Annual — Average Amount)

B	10 inches	L	8 inches
C	24	O	5
F	7	P	10
G	25	S	48
H	14	V	12
I	7	W	11

C. (Annual — Dependability)

	Sydney	Adelaide	Alice Springs	Chicago
1915	34.8	19.4	4.3	33.3
1916	44.9	28.2	13.6	34.1
1917	52.4	28.9	9.1	24.7
1918	43.0	17.4	4.2	33.3
1919	58.7	17.2	11.7	33.5
1920	43.4	26.7	28.6	30.2
1921	43.3	22.6	21.2	36.1
1922	39.4	23.2	12.8	31.6
1923	37.0	29.8	14.6	32.5
1924	37.0	23.4	5.4	35.0

B. (Monthly — Average Amount)

	Sydney	Adelaide	Alice Springs	Chicago
Jan.	3.7	0.7	1.8	2.0
Feb.	4.2	0.7	1.7	2.1
Mar.	4.8	1.0	1.2	2.6
Apr.	5.6	1.8	0.8	2.9
May	5.1	2.8	0.7	3.6
June	4.8	3.1	0.6	3.3
July	4.8	2.7	0.4	3.4
Aug.	3.0	2.5	0.4	3.0
Sept.	2.9	2.0	0.4	3.1
Oct.	3.2	1.7	0.7	2.6
Nov.	2.8	1.2	1.0	2.4
Dec.	2.9	1.0	1.6	2.1

D. (Monthly — Dependability)

	Sydney (1916)	Adelaide (1921)	Alice Springs (1919)	Chicago (1918)
Jan.	1.5	1.6	6.9	4.1
Feb.	2.7	0.6	3.3	2.8
Mar.	2.5	1.7	0.0	2.1
Apr.	6.2	0.5	0.1	3.4
May	2.3	4.6	0.1	4.6
June	2.2	2.0	0.0	1.7
July	3.3	2.0	0.0	2.7
Aug.	2.8	2.2	0.1	1.3
Sept.	4.5	3.1	0.0	1.8
Oct.	11.1	1.8	0.0	2.9
Nov.	2.6	2.2	0.6	2.7
Dec.	3.4	0.5	0.6	3.2

FIG. 3. Amount, seasonal distribution, and dependability of rainfall in contrasted sections of Australia. Sydney represents the humid orchard and dairy belt of southeastern Australia, Adelaide is in a district which grows wheat and has an average of more than 100 sheep per square mile, and Alice Springs is near the arid margin of the grazing area. For purposes of comparison, the table gives data for one station in the United States.

[8] Data from *Climatology of Australia* by Professor Griffith Taylor.

[9] Data from *Smithsonian Miscellaneous Collections*, Vol. 79 (1927).

cific directions are needed for the use of statistics, outline maps, graphs, readings, or other materials, in order that these materials may disclose the desired facts or principles. A skilful organization aims to shield the students from the discouragement arising through frequent failure, and to this end it guards against confusion in the handling of tools and materials. Third, the structure of a successful organization provides for such ex-

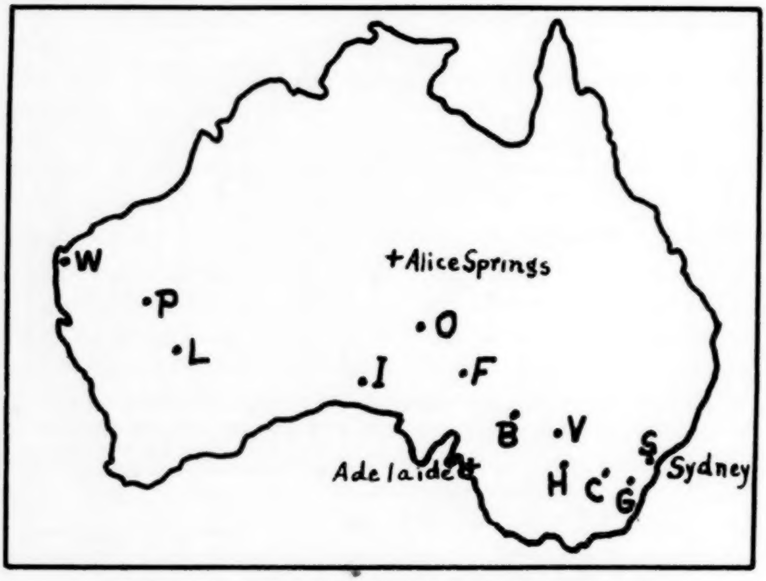

FIG. 4. Key to location of stations used for rainfall cross section of Australia.

pression as will require the students to consider thoughtfully the results of their work and demonstrate their grasp of its meaning (Principle VI). Every experienced teacher has noted that students often become so engrossed in the mechanics of constructing a graph or coloring a map as to miss entirely the significant facts depicted therein. Thus some further analysis of their work is necessary in order that the work may accomplish its educational purpose. There are many ways of combining these three parts into effective assignments. A single illustration is given here. The work called for has a dual purpose—to familiarize students with the areal spread of wool production in Australia and to acquaint them with a classification of areas according to suitability for human occupance.

THE WOOL-PRODUCING AREA IN AUSTRALIA AND ITS LIMITS

(A student investigation)

Purpose. Where are the wool-producing areas of Australia, and why are there few or no sheep in other sections of the continent? Answer these questions after finishing the map work called for below.

FIG. 5. Classification of areas in Australia.

Directions. Complete the accompanying map (Fig. 5) so as to classify the different sections of Australia according to their suitability for raising sheep. Fill in the rectangles of the *legend* with the symbols which you choose, then color the map to agree with the legend. For information, consult the maps in Figure 6, the maps in the Finch and Baker *Geography of World Agriculture*, "The Sheep and Wool Industry of Australia" by E. Pye,

in the *Journal of Geography*, December, 1927, pp. 327–342, and Chapter VII in *Australia: A Geography Reader* by Griffith Taylor. When you have finished the map, complete the sentences under "Conclusions" so as to give your answers to the questions above.

Conclusions: As I have colored it, Figure 5 shows that different sections of Australia are __________ in their suitability for raising sheep. People keep sheep only in areas where the ______________ is ______________ pasture. Most of these areas have an average annual rainfall of more than ____ inches. Wool is produced both in agricultural areas and in areas with rainfall ____________ for crops. The largest and most important sheep-raising area is in the ______________ quarter of the continent, but there is a smaller sheep-raising area in the ______________ quarter. A narrow strip along the southeastern coast produces __________ but is not suitable for ________. This strip has enough rain so that the early settlers found __________ growing there, but the climate is ____________ for sheep. Back of the coastal strip is a broad belt where people raise __________________. In the next belt they raise ______ ______ but not ___________. There the rainfall is ___________ for crops. A small area at the southwestern corner of the continent has ______________, while a little farther inland there are ____________ but no ___________. In the central part of the continent people raise __________ crops ___________ sheep. There the rainfall is ______________ and wild vegetation is ______________ for pasture. Along the __________ coast is a broad belt of tropical land where the climate is ___________ for sheep. In the frost-free belt along the northeastern coast, people raise ______________ crops, but the climate is ________ ______ for sheep.

The study of regions has its highest educational value if it culminates in the recognition of principles or generalizations having wide application, and the organization of material for teaching may well provide for such recognition. The generalizations will be corroborated or their validity challenged by later regional studies, and the attempt to apply them will aid in understanding other regions. After the study of Australia through the wool trade, for example, the students will be ready to test the validity of the following generalizations as they study other regions of scanty rainfall.

Difficulties of making a living are extreme in commercially remote areas with scanty rainfall.

Sheep are important as means for wresting a living from middle-latitude areas with rainfall too scant for crops but sufficient for some grass.

Non-perishable commodities are more suitable than perishable products for export from commercially remote areas.

The expansion of an industry into new areas is likely to involve modification in detail, and this change calls for human ingenuity and initiative.

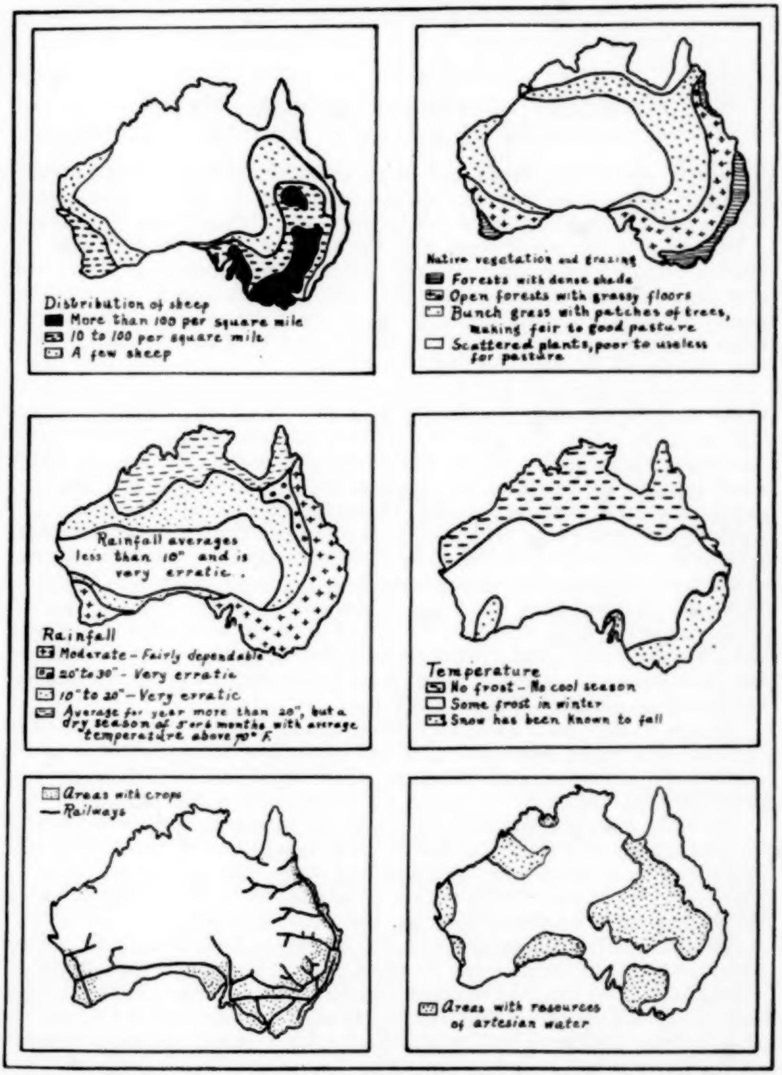

FIG. 6. Reference maps for investigation of "The Wool-Producing Area in Australia and Its Limits."

REFERENCES FOR INFORMATION REGARDING AUSTRALIA

Bean, C. E. W.: *On the Wool Track* (1910).

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———: "Agricultural Regions of Australia," *Economic Geography*, April, 1930, pp. 109–134, and July, 1930, pp. 213–242.

———: "The Frontiers of Settlement in Australia," *Geographical Review*, Jan., 1926, pp. 1–25.

GIANT TELESCOPE POURING HAS ONLY ONE SLIGHT MISHAP

Ladling out molten white hot glass, four hundred pounds at a time, like soup from some infernal caldron, workmen at the Corning Glass Works poured what they hope will be the world's largest telescope mirror.

Dozens of famous scientists and hundreds of other visitors saw the twenty tons of glass poured into the seventeen-foot mold in which it will cool until ten months have passed. Not until then will it be known whether the event was really successful. Despite the most careful preparations, there is always the chance that the large mass of glass may crack while it is cooling.

One mishap occurred but Dr. John C. Hostetter, director of research of the Corning Company, expressed the belief that it would not be serious. The mold in which the glass was poured has its bottom covered with numerous cores, making it look like a city of Eskimo snow houses. These cores were covered with molten glass in order that the finished disk will not have a solid back but a series of ridges. This permits the disk to be made much lighter than if it were solid glass and the holes formed where the cores project upwards are to be used for supporting the mirror. After about half the glass had been poured into the mold, several of the cores worked loose from their moorings on the bottom of the mold. When the doors to the fire brick "beehive" covering the mold were opened to admit more ladles of glass, they could be seen floating about on the surface of the glass inside. Dr. Hostetter said that this would not affect the success of the mirror although it was unfortunate.

As soon as the pouring was completed, the loose cores were fished out of the taffy-like mass. The whole disk will be allowed to cool without them. After cooling, this part of the glass will be solid and then holes will be drilled corresponding to the places where the cores would have been.

After the glass was poured into the mold, the entire mold was lowered on four screws into the cellar below. Then it was moved about forty feet and lifted from below into the annealing oven. The bottom of the mold and the sides and top of the oven are lines with electrical heating elements. As the current is gradually reduced, the glass will cool.

After successful cooling, the disk will be sent to Pasadena, Calif., where several years will be required to grind it to the accurate dish shape required to pick up the rays of starlight and focus them accurately fifty-five feet above. The grinding and building of the telescope will be done in the shops of the California Institute of Technology. So far the exact location of the finished telescope has not been determined, but it will doubtless be on a mountain top in southern California.

—*Science Service*

EXPERIMENTAL PRACTICES IN BIOLOGY TEACHING

BY J. WAYNE WRIGHTSTONE
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INTRODUCTION

In teaching of biology, as in all other aspects of the curriculum, controversies have arisen between two main schools of educational thinking. The implications of the two schools of thought touch not only methods but materials, or context, of instruction. On the one hand, the so-called conventional group accepts the isolated subjects of instruction as the units for classroom teaching. The content of each subject usually represents an historical accumulation of topics arranged logically. Each topic is taught according to a psychology that places an emphasis upon the acquisition of "minimum essentials" of intellectual knowledges and skills, at least for the class groups.

On the other hand, the proponents of a newer viewpoint contend that previously isolated subjects of instruction should, insofar as possible, be integrated into a new synthesis of subject matter. The method and content of the curriculum should draw upon and expand the present interests and experiences of pupils. Units of work should not be taught according to any previous logically arranged order of topics. The psychological assumptions of these educators are that meaningful experiences in the educational process arise from purposeful activity on the part of the pupils; that pupils' interests, purposes and attitudes will be considered and developed by the teacher; and that the acquisition of intellectual knowledges and skills will be incidental and correlative outcomes of properly directed and guided dynamic factors.

PURPOSES OF THIS INVESTIGATION

This investigation represents a comparison of two groups of pupils in biology, equated on the bases of verbal intelligence and socio-economic status. One group had been taught biology according to more conventional teaching practices. The other group had been taught according to newer, or experimental, practices. The problems to be solved are: What differences in measurable intellectual outcomes, such as knowledges and skills, are apparent? What, apparently, are some of the desir-

able, but unmeasured, outcomes of each type of teaching?

CONDITIONS FOR TEACHING

The teachers of biology who participated in this investigation were rated as superior by their respective administrative and supervisory officers. They had taught for a period of six to eight years. Each was convinced that his method and materials of instruction were best adapted to his philosophy of education and personality.

The classes were about equal in size, the average class being about twenty-five pupils. The pupils in the biology classes were tenth and eleventh grade pupils in high school. Their previous opportunities for instruction in the natural sciences were approximately equal. However, the pupils in the conventional group attended a high school of larger enrolment than did the experimental group. The pupils whose records were used in this investigation were chosen from several classes in biology taught by each teacher. The equating of pupils was made from natural class groups in each school.

Facilities in both schools were similar. Each school had a central school library. The equipment, such as microscopes, specimens, and the like, were adequate. The conventional school had a hot house for growing plants. The experimental school chose to use its small laboratory room for aquaria instead of plants.

THE EXPERIMENTAL PRACTICES

In brief, the experimental practices may be described thus. Instruction was carried on through a problem and project technique. However, certain goals were tentatively arranged for the pupils. These involved certain major conceptions, or generalizations, in biology. The individual student chose his problem or project around which his investigations were centered and from the study of which he was to arrive at an understanding of the conceptions or generalizations. In other words, not only the problem was individualized, but the rate of progress was individualized. Hence pupils who had a major interest in biology might enrich their experience by additional special studies and problems.

In the development of the problems and projects, the pupils either as individuals, or groups, were allowed to make excursions or visits to museums, botanical gardens, or to do field study. Many of the class periods were spent in personal investigations

of sources of data and information in the science section of the library or with books from the library. Contemporary reports on biological topics in current periodicals and newspapers were utilized in the written and illustrated report of each pupil. Whenever necessary, the microscope was used.

The pupils used self-administering tests to check upon and guide their study from time to time. Objective tests were used by the teacher for guidance and information. At the conclusion of the year a standardized subject matter test for biological information was administered.

THE CONVENTIONAL PRACTICES

Teaching practices for the conventional group were based largely upon a lecture and textbook recitation technique. That is, the course of study in biology was centered around a basal textbook in which assignments were made from time to time. The class studied, discussed, and recited as a group upon the topics assigned by the teacher.

Experiences of the pupils were enriched in the classroom largely by means of certain visual devices, such as charts, graphs, enlarged models, and motion pictures. These additional experiences were utilized in the class discussion and recitation. Very little emphasis was placed upon excursions or field trips. Personal investigations, reports, and individual progress were almost entirely lacking. Incidental references only were made to biological topics or reports in the current periodicals and newspapers.

Objective tests were used by the teacher from time to time to check upon the informational outcomes of the teaching. A comprehensive test on biological information was administered at the end of the course.

MEASURED OUTCOMES

In order to measure the outcomes in biological information, the Cooperative Biology Test, Form 1933, was administered to several classes in schools using the conventional and newer practices in teaching. Then thirty-six pupils from each school were equated roughly for socio-economic status and by more refined measures for verbal intelligence. The IQ comparisons in Table I were based upon scores from the Otis Self-Administering Test of Mental Ability. The two groups were closely equivalent for intelligence.

TABLE I

COMPARISON OF IQ FOR CONVENTIONAL AND EXPERIMENTAL GROUPS

School	Pupils	Mean IQ	SD	
Conventional	36	107.3	11.55	
Experimental	36	107.8	12.25	

TABLE II

COMPARISON OF SCORES ON COOPERATIVE BIOLOGY TEST, FORM 1933, FOR CONVENTIONAL AND EXPERIMENTAL GROUPS

School	Pupils	Mean Score	SD	Me–Mc	SE diff	Critical
Conventional	36	66.8	17.35	7.8	4.54	1.72
Experimental	36	74.6	21.05			

The mean scores on the Cooperative Biology Test, Form 1933, were: for the conventional group 66.8; for the experimental group 74.6. The experimental group achieved an advantage of 7.8 points, but when this difference of means is divided by its standard error, the critical ratio is 1.72. In order that the superiority of the experimental group may be unquestioned statistically, a critical ratio of 3 is desirable. However, the chances now are 957 in 1000 that the experimental practices will result in superior knowledge of biological information under similar conditions of instruction.

Certain unmeasured outcomes attended both types of instructional practices. In the experimental practices the experiences that the individuals gained through enriched activities of personal investigation, use of library facilities, use of current periodicals and newspapers, excursions to museums and botanical gardens, field work, writing and illustrating of reports, and participation in class discussion, stimulation of personal conferences with the teacher—all of these are difficult to appraise. The chances are that they are desirable attitudes and accomplishments.

In the conventional practices, the orderly and logical presentation of knowledge, the extensive use of visual and pictorial materials, particularly the motion picture, will have proponents who will support the good outcomes of such instructional pro-

cedures. In fact, Wood and Freeman,[1] and Brown,[2] also Arnspiger,[3] have indicated the increased outcomes of the motion picture in science teaching. Some persons may insist that the inclusion of motion picture in conventional practice is neither in keeping with nor representative of conventional science teaching. While this is true, nevertheless in this particular situation here reported, it was an essential factor in an otherwise conventional teaching procedure; hence it was impossible to exclude it and its effects from the learning of the children.

SUMMARY AND IMPLICATIONS

Conventional practices in teaching biology were appraised by comparison with newer, or experimental, practices. The conventional practices comprised a basal textbook and group recitation technique which was supplemented by visual aids, including the motion picture. The experimental practices included the use of projects, problems, individual investigations, individual progress, excursions, field trips, individual and class conferences, use of current periodicals, the writing and illustrating of the reports on individual problems, and the use of self-administered tests of information.

The superiority of the experimental group over the conventional group in biological information, as measured by the Cooperative Biology Test, Form 1933, was 7.8 points. The chances are 957 in 1000 that this is a true difference.

In addition, certain unmeasured outcomes would indicate that the experimental practices enriched the lives of the pupils by means of an acquaintance with: library resources in biology, biological information in current periodicals and newspapers, field work, and, finally, the writing and illustrating of individual reports on problems or projects.

While the present investigation can not be conclusive because of the small number of situations and pupils included, it points to the probable outcomes of future experimental practices in the field of biology. The implications are as closely related to the context as to the method of instruction. Future appraisal should include such dynamic factors as scientific attitudes and thinking besides knowledge.

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[1] Wood, Ben D. and Freeman, Frank N. *Motion Pictures in the Classroom*. Houghton Mifflin, Boston, 1929.

[2] Brown, H. E. *Motion Picture or Film Slide?* SCHOOL SCIENCE AND MATHEMATICS, Vol. 28, 1928, pp. 517–526.

[3] Arnspiger, Varney C. *Measuring the Effectiveness of Sound Pictures as Teaching Aids*. Bureau of Publications, Teachers College, Columbia University, New York, 1933.

AN ALGEBRA TEST

By JAMES DAVID TELLER, *Brighton High School, Wellington, Ohio*

PART I

SCORE = RIGHTS (10) = (......)

FUNDAMENTAL CONCEPTS

DIRECTIONS: *On the blank before each Concept listed in Column A, place the number of the descriptive phrase in Column B, which correctly relates to it; if no description correctly relates to a Concept place a zero (0) on the blank. The examples are correctly marked:*

COLUMN A

Concepts

Examples:

......6....(a.) Addend
......0....(b.) Subtrahend
..................1. Binominal
..................2. Coefficient
..................3. Difference
..................4. Exponent
..................5. Factor
..................6. Monomial
..................7. Product
..................8. Quotient
..................9. Sum
..................10. Trinomial

COLUMN B

Descriptions

1. The number 6 in the expression $6 \div 2 = 3$
2. The number 3 in the expression $6 \div 2 = 3$
3. The number 6 in the expression $2 \times 3 = 6$
4. The number 4 in the expression $6 - 2 = 4$
5. The number 6 in the expression $2 + 4 = 6$
6. The number 3 in the expression $3 + 4 = 7$
7. The expression $abcd$
8. The expression $a + b + c + d$
9. The expression $a + b + cd$
10. The expression $ab + cd$
11. The number 2 in the expression $ab^2c^3d^4$
12. The statement $a + 2 = 3$

PART II

(SCORE = RIGHTS (20) = ...)

FUNDAMENTAL PRINCIPLES OF ARITHMETICAL, DIRECTED, AND LITERAL NUMBERS

DIRECTIONS: *On the blank before each problem, place the correct answer of the problem. Indicate all negative signs and decimal points clearly. Reduce common fractions to lowest terms. The example is correctly marked:*

Example:

....**.75**....(a.) $.5 + .25 = ?$

..............1. $.66 + .3 = ?$
..............2. $.66 - .3 = ?$
..............3. $.66 \times .3 = ?$
..............4. $.66 \div .3 = ?$
..............5. $\frac{2}{3} + \frac{1}{4} = ?$
..............6. $\frac{2}{3} - \frac{1}{4} = ?$
..............7. $\frac{1}{4} \times \frac{2}{3} = ?$
..............8. $\frac{1}{4} \div \frac{2}{3} = ?$
..............9. $(-4) + (-2) = ?$
..............10. $(+4) + (-2) = ?$
..............11. $(-4) - (-2) = ?$
..............12. $(-2) - (-4) = ?$
..............13. $(-4) \times (-2) = ?$
..............14. $(-4) \times (+2) = ?$
..............15. $(-4) \div (-2) = ?$
..............16. $(-4) \div (+2) = ?$
..............17. $6a + 2a = ?$
..............16. $6a - 2a = ?$
..............19. $a^6 \times a^2 = ?$
..............20. $a^6 \div a^2 = ?$

Part III SCORE = RIGHTS (*20*) = (........)

Fundamental Operations with Algebraic Expressions

DIRECTIONS: *On the blank before each problem in Column A, place the number of a correct answer in Column B; if no answer is correct, place zero (0) on the blank. Perform all calculations in Column C. The examples are correctly marked:*

Column A *Problems*	Column B *Answers*
Examples:	
.12 (a.) $3a-2a+b=?$	1. a
. 0 (b.) $3a+2a+b=?$	2. $2a$
.....1. $3a-2a+a=?$	3. $3a$
.....2. $3a+2a-a=?$	4. a^2
.....3. $3a+(2a+b)=?$	5. $2a^2$
.....4. $3a-(2a+b)=?$	6. a^3
.....5. $2ab-ab=?$	7. $3a^3$
.....6. $3a^2-2ab+b^2-2a^2+2ab-b^2=?$	8. $a+3$
.....7. $2ab\cdot ab=?$	9. $a-2$
.....8. $a(a+b)=?$	10. $2a+3$
.....9. $a(a+b-2)=?$	11. $3a-2$
....10. $(a+b)(a-b)=$	12. $a+b$
....11. $(a+b)(a+b)=?$	13. $a-b$
....12. $6a^2\div 3a=?$	14. $2a+b$
....13. $(ab+b)\div b=?$	15. ab
....14. $(a^2+5a+6)\div(a+2)=?$	16. a^2b^2
....15. $\frac{a^2}{b}+\frac{b^2}{a}=?$	17. a^2-b^2
....16. $\frac{a^2}{b}\cdot\frac{b^2}{a}=?$	18. a^2+b^2
....17. $\frac{a^3}{b^2}\div\frac{a^2}{b^3}=?$	19. a^2-ab+b^2
....18. Find a factor of a^3+3a^2+2a	20. $a^2+2ab+b^2$
....19. Find a factor of $4a^2-b^2$	21. $a^2-2ab+b^2$
....20. Find a factor of a^2-a-6	22. $2a^2+ab-3b^2$

Column C

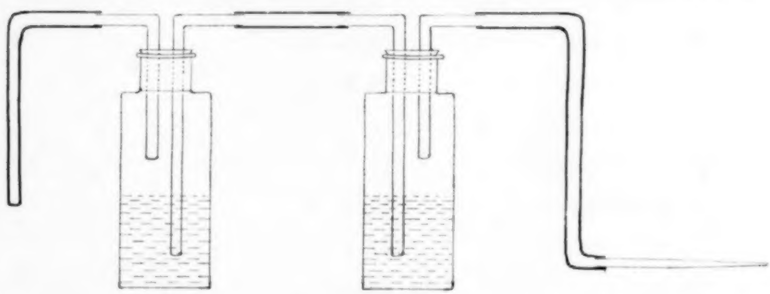
Do all work in this space.

A SIMPLE MICRO-PIPETTE

By Thomas F. Morrison
Milton Academy, Milton, Massachusetts

It is frequently desirable, especially in the biological laboratory, to have some means of removing individual protozoa from a culture. Such a procedure is rather difficult with the usual pipette, and it is not generally within the possibilities of the average high or private school to supply one of the more costly instruments which are sold for this purpose. The instrument which is described in this note is of very simple construction and well within the limits of any school. The versatility of its use depends entirely upon the amount of skill developed by the operator.

Two wide-mouth bottles of about one liter capacity each are equipped with two-hole stoppers. Both are filled to the same level with water, and through one of the holes in each stopper there is placed a glass tube which reaches well below the surface



of the water. Through the other hole in each stopper is run a glass tube which remains some distance above the water level. All four tubes have right-angle bends, the horizontal arms being sufficiently long to permit the attachment of rubber tubing. The two tubes which reach below the surface of the water are connected by a short piece of rubber tubing, while longer pieces are attached to the free ends of the other glass tubes. To one of the rubber tubes there is attached a finely drawn glass pipette, while the operator places the end of the other tube in his mouth. When air is sucked from one bottle, water will flow from the other thereby creating a suction in the pipette. If the bottles are quite wide, the water thus displaced moves very slowly setting up a gentle current in the pipette, and after some little practice the operator will be able to collect a single protozoan with

it. By simply blowing in the end of the tube which the operator holds in his mouth, the direction of the flow of water is reversed and the specimen is ejected.

The writer feels that this type of pipette is superior to the usual hand type because it permits greater ease in handling small specimens, and, if the tip of the pipette is drawn sufficiently small, it may be used under the compound microscope. Due to the capillary action which will be apparent in the small tip, a very slight positive pressure should be maintained until just the instant when the particular form to be collected comes near the end of the tube.

GEOLOGY FIELD TRIPS IN ILLINOIS

With a field trip on Saturday, May 12, in the region south of Chicago, the State Geological Survey will inaugurate its fifth annual series of earth history field conferences for science teachers of Illinois.

Six of these trips are given in various parts of the State each year as a free extension service, hundreds of people participating in these educational excursions.

During 1933 more than 700 teachers, and others interested in natural science, attended trips held in the vicinities of Kankakee, Gibson City, Macomb, Belleville, Granville, and Galena. The Galena trip, held in October, attracted 258 persons.

The excursions are planned and conducted by geologists on the staff of the Geological Survey, and supply authoritative information on the geology, geologic history, physiography, and mineral resources of local areas throughout the State.

All the trips are held on Saturdays and begin at 9:00 A.M. Central Standard Time. Those who attend provide their own means of transportation and bring packed lunches.

The complete schedule for 1934 is as follows:

(1) Region South of Chicago—May 12
Group meets at Thornton Community High School

(2) Ottawa Region—May 19
Meeting place, Ottawa Township High School

(3) Savanna Region—September 22
Meeting place, Savanna High School

(4) Lawrenceville Region—September 29
Meeting place, Lawrenceville High School

(5) Havana Region—October 6
Meeting place, Havana High School

(6) Hardin County Region—October 13
Meeting place, Rosiclare High School

Further information regarding individual trips may be secured by addressing Don L. Carroll, Associate Geologist, State Geological Survey, Urbana, Illinois.

THE CHEMISTRY OF STARCH FORMATION AND ITS APPLICATION

By Henry B. Kellog
Assistant Director, Warner Laboratories, Newark, New Jersey

The familiar term "starch" is applied to a large group of complex substances. The starches include corn starch, wheat starch, potato starch, rice starch, cassava starch, animal starch and many others. The granules of starch from these different origins are all of characteristic shapes and sizes and are readily identified under the microscope as shown in figure 1.

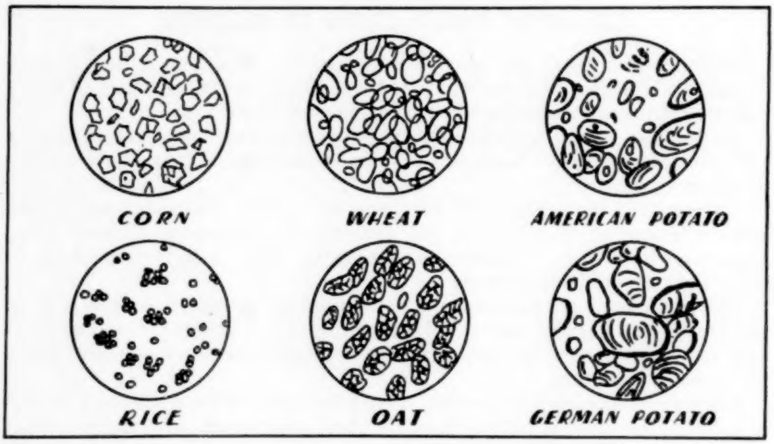


Fig. 1. Microscopic Structure of Starch Granules.

The empirical formula for all them being $(C_6H_{10}O_5)_x$. They are usually tasteless, amorphous (non-crystalline) and insoluble in water. All have the same composition and a high molecular weight and as yet no possible means has been found to determine their true formula, much less their constitutional formula.

The complexity of the formation of starch in plants is one of the most interesting and difficult studies. Starch is found in all green plants. It is present in the plant cells in the form of small colorless granules of various rounded shapes.

In order to produce starch the green plants require raw materials which they utilize in their metabolism including carbon dioxide and oxygen from the air and inorganic salts and water which come from the soil through the roots. In conjunction with

these raw materials energy must be furnished by the sunlight and a catalyzer, chlorophyll. The reaction involving sunlight energy and chlorophyll is termed photosynthesis.

The process of photosynthesis was discovered by Ingenhousz, a Dutch physician, in 1799. When green leaves are in the sunlight they absorb carbon dioxide from the air and give off oxygen through microscopic openings called Stomata found in the surface of the leaves. Figure 2.

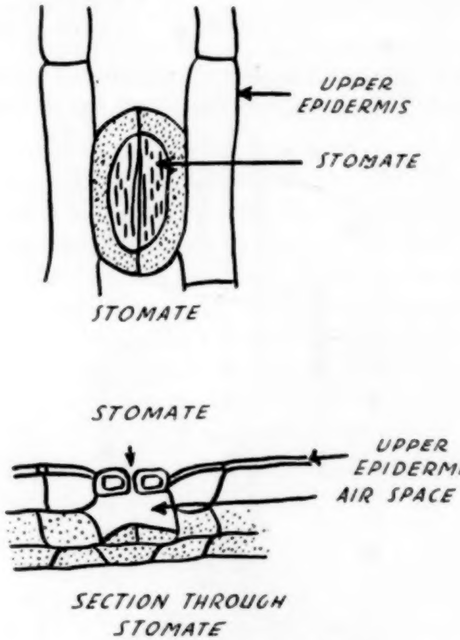


FIG. 2. Leaf Structure.

All plants especially the flowers and fruits whether in sunlight or dark engage in the reverse process. They absorb oxygen and give off carbon dioxide. In the sunlight the former process predominates in green leaves. In dim light or in the dark the two processes just about balance.

Photosynthesis in the sunlight

$CO_2 + H_2O \rightarrow Starch + Sugars + O_2$

Respiration at all times.

$Starch + Sugars \xrightarrow{O_2} CO_2 + H_2O$

The phenomenon of photosynthesis involves chlorophyll, the green coloring matter of leaves, which acts as a catalyzer and

carrier of energy in the reactions in which the starches and other organic matter is produced. Chlorophyll is a mixture of two amorphous pigments both of which are complex organic compounds containing magnesium.

$$(C_{32}H_{30}ON_4Mg)\begin{cases}COOCH_3\\ COOC_{20}H_{39}\end{cases}\quad \text{Chlorophyll (black-blue)}$$

$$(C_{32}H_{28}O_2N_4Mg)\begin{cases}COOCH_3\\ COOC_{20}H_{39}\end{cases}\quad \text{Chlorophyll (dark green)}$$

Chlorophyll is produced in the leaves from the storage material of the seed. The conditions necessary for its formation in-

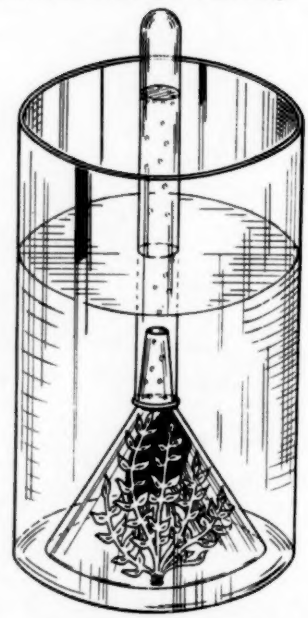


FIG. 3. Placing a green plant under water in a jar, and setting the jar in the sunlight, bubbles of oxygen gas appear on the leaves which grow into larger bubbles and finally detach themselves and rise to the top of the test tube displacing the water. The gas relights a glowing splinter of wood, and is pure oxygen.

clude inorganic nutrients (notably iron) which do not enter into its composition, light of medium intensity, suitable temperature and oxygen. The formulae of chlorophyll as written here are still tentative.

The two types of chlorophyll are always associated in plants with two yellow pigments; at times with a red-brown pigment

as well. Plants which have yellowish or reddish foliage do not lack chlorophyll but contain a great deal of other pigments which conceal it. When seedlings are deprived of iron, the chlorophyll does not form properly. The leaves remain yellow and suffer from "chlorosis." The chemical transformations of photosynthesis are carried on in structures named chloroplasts, which are scattered through the leaf cells. When the sun shines upon the chloroplasts they absorb CO_2 and give off oxygen and produce soluble sugars and ultimately starch.

There are a number of factors which are known to influence the rate of photosynthesis. The rate at which the chloroplasts synthesize the raw materials depends on the wave length and intensity of the light. Only light which is absorbed can cause chemical change. Light which is not absorbed by chlorophyll (or the other pigments of the chloroplasts) cannot be effective in photosynthesis. However all light absorbed is not necessarily effective. The most recent investigation indicates that the light which is absorbed in the red and yellow portions of the spectrum is more effectively utilized than that absorbed in the violet region. Plant leaves differ widely in their ability to carry on photosynthesis under different light conditions. Not only are there "shade" plants, which thrive in comparatively low illumination, but plant leaves may be made to adopt themselves in the cause of time to lower or higher intensities of illumination.

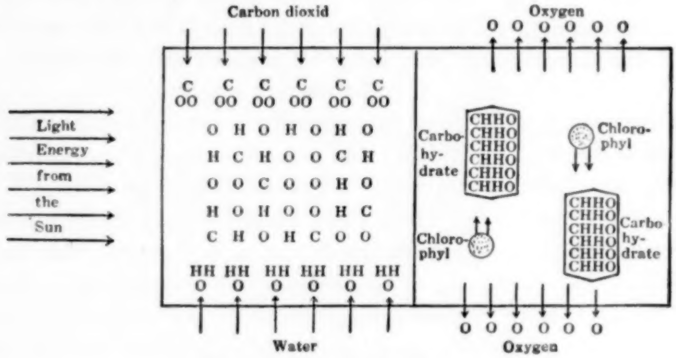
The amount of carbon dioxide necessary depends upon the plant and conditions of illumination, number of chloroplasts and the amount of chlorophyll they contain, the temperature, water supply and numerous other factors. For most plants a temperature of 30° to 40°C is most favorable to photosynthesis.

The chemical transformation involved in photosynthesis is a complex process and not yet perfectly understood. The reactions discussed here are merely hypothetical. The various intermediate products which have been suggested by different investigations are speculative. Some of the products are formaldehyde, formic acid, carbon monoxide, glycollic aldehyde, etc.

Due to the fact that formic acid (HCOOH) and formaldehyde (HCHO) have been converted into sugars or near sugars, under the influence of ultra-violet light or of sunlight suggest a plausible explanation. Though the reactions are very incomplete nevertheless they will be explained to the reader as a means of understanding the reaction involved.

During the assimilation of the carbon dioxide by the plant it

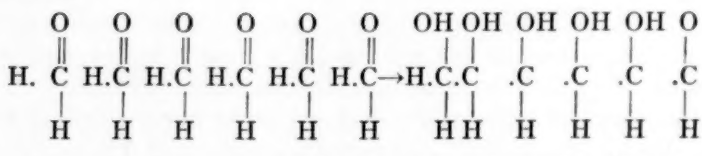
must be reduced. The carbon dioxide enters the stomata of the leaves while the water ascends from the soil through the roots and stems. The chlorophyll and protoplasm in the leaves act upon the carbon dioxide causing oxygen to be liberated which is shown diagrammatically as follows:



$$CO_2+H_2O \rightarrow H.CHO_3$$
$$H_2CO_3 \longrightarrow H.CHO+O_2$$

Carbon dioxide combining with water to form carbonic acid. The carbonic acid is reduced to formaldehyde, and oxygen is liberated.

The six molecules of formaldehyde combine together, or polymerize to form a sugar (or rather a mixture of sugars) $C_6H_{12}O_6$.



Six molecules of formaldehyde→One molecule of sugar

These sugars lose a molecule of water, and polymerize further to form starch $(C_6H_{10}O_5)_x$ and cellulose $(C_6H_{10}O_5)_y$ which is the principal constituent of the cell walls of plants and the framework of the tissues.

$$nC_6H_{12}O_6 \rightarrow nH_2O+(C_6H_{10}O_5)n$$

Reverse reactions also take place in the plant. The starch which first accumulates in the leaves is later turned back into a sugar soluble in the sap, and is able to pass to the parts of the plant requiring new material. Some of the carbon dioxide and

water in the form of moisture is also liberated from the plant surfaces by oxidation of the sugars.

$$C_6H_{12}O_6 \rightarrow CO_2 + H_2O$$

The chief source of our starch supply is that derived from the corn kernel. Its manufacture occupies a predominating position in our industrial structure. No other industry of similar magnitude is so purely American in origin and development for even the early American explorers found the Indians cultivating corn. Columbus writing to Ferdinand and Isabella of Spain mentions corn fields 18 miles in length. Even in those days it was a staple crop grown in what are now our Eastern and Central states.

Today one factory alone in our country is capable of grinding 80,000 bushels of corn in 24 hours. The corn ground daily yields 12,000 gallon of refined corn oil, the starch obtained is 1100 tons, 40% going to the dry starch department to be made into numerous brands and grades used for food and technical purposes.

The corn is removed from the cob. It is then soaked in warm water containing a little sulphur dioxide, which helps soften it and prevents fermentation while soaking. This water is taken off the corn and boiled down, later it is used in another process. The now soaked kernels are passed through a mill where they are partially ground up, enough to free the germ which is the portion containing nearly all the oil, making it lighter than the crushed outer portion of the corn. When water is again added to the crushed mass these germs float on top and are removed for a separate purpose, namely that of extracting the corn oil.

The crushed portion of the kernel in water is now passed through mills which continue the grinding of the corn. The product is then filtered through silk cloth to remove the fibrous outside of the corn. The liquid carrying the starch and gluten passes through the silk while the fibrous material is retained by the cloth. This liquid is then run into troughs. The gluten being lighter than the starch remains on top while the starch settles to the bottom of the troughs. The starch is taken from the troughs, called settlers, and is further washed and purified. It is then passed through filter presses to remove the moisture, thence to starch kilns where a current of air circulating through it completes the drying process. Different types of starches as pearl, crystal, etc. are obtained depending on the method of

drying used and the length of time allowed for the drying. Thus to summarize we get five products from a corn kernel, namely:

1. Hull or skin
2. The soluble protein matter separated in the soaking water.
3. The germ which contains the oil.
4. The gluten
5. The starch, which makes up 65% of the total grain.

Ordinary corn starch is that taken directly from the troughs. Laundry starch is made by partly cooking this then pressing in cylinders at 800 pounds pressure for 30 hours after which it is broken up and packed. Crystal starches are made for special laundry purposes by converting it to the soluble state and then filtering and redrying.

The most interesting part is the Refinery. Here the starch is converted by hydrochloric acid into products of lower or higher dextrose content. Much of it is converted by hydrolysis, a reaction in which a substance is resolved into simpler ones by reaction with water which is one of the reagents. The hydrolysis is catalysed by the acid.

$$(C_6H_{10}O_5)_x + H_2O + HCl \rightarrow (C_6H_{12}O_6) + HCl$$

(excess acid is neutralized by sodium carbonate)

The now neutral solution is filtered, concentrated to a syrup by evaporation in a vacuum then decolorized by boneblack. The product is not glucose but dextrin with smaller proportions of maltose and glucose. The purpose is to have sufficient dextrin gum in the syrup to prevent the glucose from crystallizing out of the confectionary in which the syrup is used and enough maltose and glucose to give the mixture considerable sweetness, and thus save on cane sugar.

This process is highly technical and requires the constant testing and supervision of chemists as it requires a series of delicate operations for successful manufacture. This phase most closely resembles the physical changes which take place in the animal digestion of starch. Our body's supply of starch is not limited to corn alone, however corn and potatoes make up the chief commercial sources as these vegetables contain starch in more abundance than do other plants.

When corn or starchy foods enter our mouths they go through the grinding process by our teeth (i.e., molars) and is moistened by the saliva which contains an enzyme. An enzyme is a catalyzer and exerts its properties not by uniting with a given sub-

stance to form a new substance but by exerting an influence. It is an inhibitor or promoter leading chemical compounds to turn themselves into something different. The action of this enzyme is astonishingly rapid. One may test this reaction by chewing a piece of cracker. The saliva through its digestive enzyme ptyalin, is amylalytic; that is it digests starch exclusively. It does so by breaking down the complex starches into simple sugars. So after five seconds after the cracker has been in your mouth it will show positive tests for sugar which it did not previously show. The higher complex starch of the cracker has been converted into maltose.

Aside from its food value starch has found extensive industrial uses among which are the following: It is an essential ingredient for finishing sizes in the textile industries. It has manifold uses in the cosmetic, paste and adhesive trades. Its chief chemical importance, however, is its adaptability to bacterial fermentation which converts it into solvents used for numerous chemical applications. The starch is thoroughly cooked in water and then converted by the action of special bacteria into solvents such as butanol, acetone, and ethyl alcohol. As the starch ferments large volumes of gases, hydrogen and carbon dioxide, are produced. These are converted under pressure into Methanol (synthetic wood alcohol). The excess carbon dioxide is converted into "Dry Ice" used extensively for refrigeration purposes.

From the four primary products, butanol, acetone, methanol, and ethyl alcohol many useful chemical compounds are manufactured.

Thus we see how important starch is to us, not only as an important food constituent but as a starting point for other chemically applicable and industrially useful substances.

CANCER, SEX, VITAMIN AND DRUG HAVE CHEMICAL SIMILARITY

Cancer, sex, one of the vitamins and certain drugs all have a chemical kinship to each other, Prof. Marston T. Bogert of Columbia University reported to the American Chemical Society. In the course of his investigation of the polycyclic hydrocarbons, which are highly complex compounds of carbon and hydrogen, he found that one group of atoms, known as the phenanthrene nucleus, is present in the tarry substances that provoke one form of cancer, in both male and female hormones, in vitamin D, and in some of the alkaloids like those of the morphine group.

—*Science Service*

TEACHING SCIENTIFIC METHOD

Article III: The Percent of Oxygen in the Air

By Wilbur L. Beauchamp
The University of Chicago, Chicago, Illinois

Textbooks in general science commonly include directions for performing experiments in the body of the text. If the text is well written the experiment is included at a point where additional data are needed to pursue the investigation of some problem. The experiment is thus a means to an end, the end being the solution of some problem. In addition to providing data the experiment may also be thought of as a means for securing a better understanding of the scientific method. The experiments in text books, however, are limited to statements of the procedure to be followed. To teach the experiment is an entirely different matter from merely following directions. The following description is an attempt to show how an experiment may help the pupil to understand and apply the scientific method.

The pupils in the class have been studying the nature of burning. They know that burning and rusting are similar in that both are caused by the combination of oxygen with a material. They have prepared oxygen and know something of its properties. The purpose of the experiment to be discussed is to discover the per cent of oxygen in the air. The text gives directions for performing the familiar experiment in which iron filings are scattered over the inner wall of a test tube and the tube is inverted in a beaker of water.

The instructor follows the directions in the text and sets aside the beaker for observation on the following day. His procedure is then to ask a question which each pupil answers in writing, followed by a discussion of the answer by the group. This procedure is followed throughout with each question raised.

The first question asked is, "What will happen if something is taken from the air? Why?" The pupils have studied air pressure and this question is asked to be sure that pupils understand why the rise of water in the tube indicates that something has been taken from the air. The answer to this question is then discussed by the whole class and another question is raised, "Are there any other reasons why water might rise in the tube?" The purpose of this question is to bring out the idea that changes in air pressure or temperature might have the same effect as loss

of oxygen. The third question is, "How can we control the experiment so that we may be certain that the rise of the water in the tube is due solely to the withdrawal of part of the air in the tube?" The purpose of this question is to direct the pupil's attention upon the necessity of a control which will eliminate the possibility of other factors affecting the results. The fourth question is, "Will the fact that the water rises in the tube prove that it is oxygen which has been removed from the air?" The purpose of this question is to indicate the necessity of some test to identify the presence or absence of oxygen in the tube. The fifth question is, "How can you prove that it is oxygen?" The pupils must recall information concerning the characteristics of oxygen to devise a test for its presence or absence.

The second part of the experiment deals with the measurement of the amount of water which rises in the tube. The directions state that the tube should be held so that the water levels inside the tube and the glass are the same. The question is raised, "Why must the water levels be the same?" The next questions are, "Would it really make a difference in the results if the water levels were not the same?" "How could you prove this?" At this point, an experiment is tried which shows that the results would be affected. This focuses attention on the necessity of following directions exactly. The next questions are, "Does the rise of water in the tube containing iron filings and the failure of the water to rise in the tube containing no iron filings prove that oxygen has been taken from one tube and not the other?" "If not, how can you prove that this is true?" The attention of the pupil is thus focused on the necessity of verifying his hypothesis through further testing.

In the third part of the experiment the pupil is directed to make his computations of the per cent of oxygen in the air by dividing the length of the water column in the tube by the length of the entire tube. The questions raised are, "How do our results compare with the results obtained by scientists?" "Why are our results likely to be inaccurate?" Attention is directed here upon the crudeness of the measuring instruments, the small end of the tube, the possible loss of water when removing the tube and other possible errors. The questions focus attention upon the necessity of refined apparatus and skill in handling to secure accurate results.

The method just described is entirely different from saying, "We will now do Experiment 7" or "We will perform a demon-

stration to discover the percent of oxygen in the air." As a result of the procedure described the pupils should be made conscious (a) of the necessity for carefully following the directions, (b) that every step in the directions have been carefully worked out to provide a given set of conditions, (c) that any variations in the conditions will change the final results, (d) that the experiment must be so controlled that the results obtained can be traced to a single cause, and (e) that the results of the experiment are only approximate because of the crudeness of the measuring instruments and the technique.

The example just described, in the judgment of the author, is one method of focusing the attention of the pupil on the scientific method. To be of any value such a method would have to be used with many experiments. Continued emphasis on the technique of experimentation as an integral part of every experiment should result at least in a more adequate understanding of scientific method.

THE 15TH ANNUAL MEETING OF THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS CLEVELAND, OHIO, FEB. 23 & 24, 1934

EDWIN W. SCHREIBER, *Secretary*

The following papers were presented at the 15th annual meeting: "The Future of Geometry in the High School" by Ralph Beatley; "The Future of Geometry in the High School" by Roland R. Smith; "A 'Panel' Discussion of the Present Crisis in Secondary Mathematics" by 10 members of the Board of Directors; "The Problems of Ability Grouping, Administrative Phases" by C. M. Stokes; "Remedial Work in Arithmetic" by Genevieve Skehan; "Problem of Individual Differences" by Clara E. Murphy; "An Experiment in Teaching Graphs" by Mrs. W. E. Pitcher; "What Can We Do to Meet the Challenge of the Present Situation in Secondary Mathematics" by William D. Reeve; "A Report of the Policy Committee" by J. O. Hassler; "Mathematics and Music" by Prof. Carl A. Garabedian.

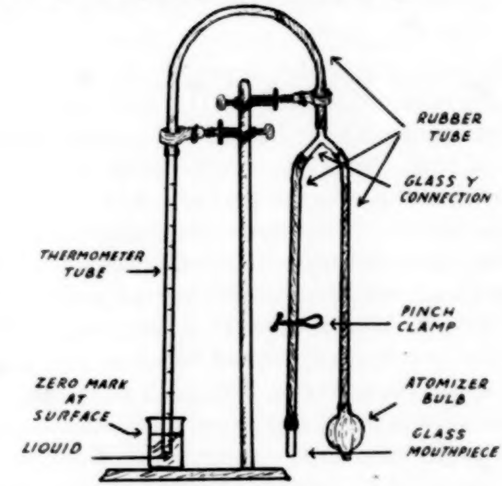
The results of the annual election: President, J. O. Hassler, Prof. of Mathematics, University of Oklahoma; Second Vice-President, Allen R. Congdon, University of Nebraska; Members of the Board of Directors, William Betz, Rochester New York, H. C. Christofferson, Oxford, Ohio, Edith Woolsey, Minneapolis, Minnesota, Martha Hildebrandt, Maywood, Illinois.

The National Council of Teachers of Mathematics, which had a very modest beginning in Cleveland, Ohio, February, 1920 when approximately 75 members (charter members) created the organization, has now grown to a membership of many thousands, including every state in the union and some 20 foreign countries.

A NEW SURFACE TENSION EXPERIMENT

By Oscar L. Starr
San Diego Army and Navy Academy
Pacific Beach, California

These are several methods of determining the surface tension of a liquid, and the usual laboratory course in college physics includes one or more of these in its experiment list. The method to be described here is one which we have found useful as a laboratory experiment; and since it can be set up quite easily, with practically no expense, we pass it along.



SURFACE TENSION APPARATUS

The apparatus consists of a thermometer tube, connected to a rubber tube. This rubber tube is then connected to a glass "*T*" or "*Y*," and a tube is attached to each arm of the "*Y*." One of these tubes ends in a glass tube or mouthpiece, with a pinch clamp on it, while the other ends in an ordinary atomizer bulb. The whole apparatus is then mounted on a ring stand as shown in the diagram. The thermometer tube is preferably an 0–50° Centigrade, graduated in tenths of degrees, but any laboratory thermometer tube will do.

The apparatus works on the theory that the height to which a liquid will rise in a tube depends on three factors; viz., the surface tension, the density, and the value of "*g*." This relation is clearly shown in the familiar equation, $T = rhdg/2$, where h is

the height the liquid rises (centimeters); T is the surface tension in dynes per centimeter; r is the radius of the tube; d is the density in grams per cc, and g is the acceleration of gravity.

In this experiment, r and g are constants, so we may write the above equation thus, $T = Khd$, where $K = rg/2$.

In using the apparatus, the first thing to do is to find the value of K. This is done as follows: first, wash the tube out with dilute nitric acid. This is done by placing a very small beaker of the acid on the stand as shown in the diagram. The acid is run rapidly up and down the tube by the use of the mouthpiece and the bulb. It is sucked up by the mouthpiece, and forced down by pressing on the bulb. After the acid washing, the tube is washed with ammonia in like manner. Then it is washed out with distilled water, the beaker removed, the drop at the bottom of the tube removed with a blotter, and the tube dried by forcing air through it with the bulb. All this is simply to get the tube clean and dry. Now the small beaker is replaced and partly filled with ether, or some similar liquid of which the surface tension is known. The thermometer tube is then pushed down into it until the zero mark on the thermometer tube is seen just at the surface (looking up from the under side). The ether is then worked up and down the tube a few times, and then left alone (with the pinch clamp open) to come to rest. After a minute or so it will cease to rise. This position is read, and then it is drawn above this mark and allowed to settle back to it. In a short time it will drop to the same point. Now for ether we know the surface tension and the density; therefore we put these values for h and d in the equation, $T = Khd$, and solve for K. We may use the reading in degrees on the tube directly as the height for h, without reducing to actual centimeters, if we are only going to use the data to find the surface tension of other liquids.

To determine the surface tension of any other liquid, we remove the ether, dry the tube as before, and then put the new liquid in place, and manipulate it the same as we did the ether. After finding the height to which it rises (after thoroughly wetting the tube with it), and after determining or finding out in some way its density, we are ready to get the surface tension. Since we now know K, h, and d, we simply put these in the equation $T = Khd$.

If desired, we may also determine the radius of the tube from the ether data. In this case the value of h must be reduced to

centimeters from the height as read on the thermometer tube. Then in the equation, $T = rhdg/2$, r is the only unknown quantity, and so may readily be determined. This value of the radius may then be checked by repeating the experiment with another liquid whose density and surface tension are known.

Some liquids are quite slow in reaching their limit when either rising or falling. But liquids such as ether, alcohol, carbon tetrachloride, etc., are very satisfactory.

LIME SULPHUR SPRAY

By Charles H. Stone
Memorial High School for Boys, Boston, Massachusetts

The damage done by insects and fungous growths in the United States is appalling; it runs into hundreds of millions of dollars. Science has done much to check these ravages by providing such insecticides as: Paris Green, Lead Arsenate, Kerosene Emulsion, and Bordeaux Mixture. But the natural rate of increase of these pests is so alarmingly great that, even with these destructive agencies at our command, the entomologists tell us that, unless more effective measures are found, the time is coming when there must be a show-down as to whether man or insect is to win in the struggle for existence

There are two kinds of insect pests: the "biting bug" and the "sucking bug." The former eats the leaf of the plant and consequently all that is upon it or in it. The substances listed above are effective agencies for the destruction of such pests. The "sucking bug," however, only punctures the leaf surface and draws out the juice or sap of the plant; he is not affected, very much therefore, by surface poisons. Against the "sucking bug" the insecticides listed above are not very effective. Some other means must be found to combat this type of pest. Lime-sulphur spray has been of value against this type of insect and against certain fungous growths. The spray may easily be prepared in the laboratory as follows:

Put 20 grams of fresh powdered slaked lime into a large evaporating dish with 10 grams flowers of sulphur and 100 ml of water. Heat over asbestos gauze on a tripod, not on ring of stand, stirring often and replacing the water that boils away.

Do not stand the dish on the large ring of stand for if the hot rim of the dish comes against the cold upright of the stand, the dish will probably crack. The liquid in the dish will presently become yellowish due to the formation of the polysulphides of calcium, CaS_4 and CaS_5. The color will deepen as the process goes on. Continue the gentle boiling until no further deepening of color is seen. Filter off the undissolved material and evaporate the filtrate without boiling to about 25 ml. Filter and preserve the liquid product. The colored liquid does not keep well. This spray is effective against the San José scale.

The following theory was given to the writer by a representative of the United States Department of Agriculture. The sulphides of calcium, whem sprayed upon the foliage, break down presently into calcium sulphide and free sulphur which is in an extremely minute condition. This almost atomic sulphur reacts with oxygen in the air to form sulphur dioxide, the reaction occurring in a manner similar to that of the pyrophoric metals in contact with air. The sulphur dioxide so formed combines with the dew or other moisture on the leaf to form sulphurous acid. This acid then destroys the insect. It may be questioned whether this theory is tenable. It has been contradicated by others in official Government positions.

Another explanation is this; the finally divided sulphur on the surface of the leaf is stirred up by the insect as it crawls around; the minute particles of the sulphur are drawn in to the breathing tubes of the insect until they are completely clogged when, of course, the insect dies. This seems the more reasonable theory.

The preparation of lime-sulphur spray is easily carried out in any ordinary laboratory. The preparation of this spray is of interest to both teacher and students, and is of especial interest in the rural school. There is absolutely no danger in the preparation of this spray.

NEW VITAMIN NECESSARY TO GROWTH DISCOVERED

An apparently new vitamin B factor which makes rats grow, found in whole wheat by Nellie Halliday and Linnea Dennett of the Michigan Agricultural Experiment Station was reported to the American Institute of Nutrition. Animals fail to grow and develop certain nervous symptoms when this vitamin is lacking from their diet. The vitamin is not the familiar B one nor vitamin G, but resembles that known as B four.

—*Science Service*

A RATIONAL PRESENTATION OF SUBTRACTION IN ELEMENTARY ALGEBRA*

By Susie B. Farmer

Central High School, Bridgeport, Connecticut

As we look back upon the past quarter of a century, we can view with great satisfaction our progress in the movement to vitalize the mathematics of the secondary school. During this time we have focussed our attention largely upon the mathematics of the ninth year. In consequence, the mathematics of this year has undergone, no doubt, a more complete change than that of any other year of the secondary period. As we compare the first year algebra texts of today with those of fifteen or twenty years ago, we find a decided change from the excessive emphasis upon manipulation with the attendant rules and cases to a more wholesome selection and treatment of subject matter. But we must not stop here with our present attainments. To be progressive we must feel that there is always room for improvement. Perhaps our most unpardonable offense against progressive methods is our continual acceptance of logical order and presentation of the four fundamental processes as treated in the algebra texts of today (with but few exceptions) and consequently as taught by the majority of us for lack of inclination to change. Let me hasten to say, however, that we have done an indisputably good piece of work in teaching meaningful addition but we have been particularly remiss in our treatment of the subtraction process. Through this process we may lead our pupils to a consumate understanding and appreciation of algebraic number but not by *changing the sign of the subtrahend and proceeding as in addition*. Having searched for a method more satisfying and more consistent with progressive mathematics teaching, may I offer to you what I have found to be a rational treatment of the subtraction process.

Before launching upon a specific method of presentation, we might recall that mathematical symbols came into being because of ideas and not ideas because of mathematical symbols. Let us remember, too, that the use of signed numbers has been of slow development. Hence, we must subordinate symbols to ideas and let the intricacies of the subtraction process become clear through a slower and more natural development.

* Presented before the 29th annual meeting of the Association of Teachers of Mathematics in New England held at Boston University December 5, 1933.

If our algebra is to be of natural growth and properly motivated, we shall have in the first few weeks the formula and the simple fractional equation arising from problems of the indirect case of percentage as $.15n=3$ or $\frac{1}{3}n=8$. We may have also a chapter on ratio and proportion including simple fractional equations arising from numerical trigonometry before we have any need for applying either addition or subtraction in solving equations. In our problem solving we shall then meet with such equations as

(1) $x-2=5$ (2) $x+3=7$ (3) $2x+3-x=4$

(4) $3x+2+x-3=7$ (5) $x-2+2x-3=1$.

You will notice that these equations involve only signs of operation—addition and subtraction. In the first, 2 has been subtracted from x and we have a quantity which is 2 less than x. To find x we shall add 2 to each member and obtain $x=7$. In the second equation we have the value of 3 more than x, so we shall subtract 3 from each member and get $x=4$. In the third we are first required to add 3 to $2x$ and then take away x. Following these directions, we get $x+3=4$. Subtracting 3 from each member to obtain the value of x, we get $x=1$. In this type of equation, then, we first have need for addition and subtraction which, as you see, are the already familiar operations of arithmetic. In example 4 we are required to add 2 and subtract 3, which is the same as subtracting 1. Hence we have $4x-1=7$. In example 5 we are required to subtract 2 and then to subtract 3, which is equivalent to subtracting 5. The resulting equation is $3x-5=1$. These two equations are now in the form of equation (1).

Soon a more complex situation in subtraction will arise in our problem solving. For example,

$$5x-(x+2)=6 \quad \text{and} \quad 5x-(x-2)=6.$$

The first equation is easily solved when the pupil realizes that the quantity $(x+2)$ is to be subtracted from $5x$ but the second presents difficulty. Let us first examine analogous situations in arithmetic. If we were to subtract orally in the following cases:

(1) $78-22$ we would think $78-20-2$ which is

$$78-(20+2)$$

(2) $56-18$ we would think $56-20+2$ which is

$$56-(20-2).$$

Referring to the algebraic situations again and generalizing, we learn in the first equation that 2 more than x is to be subtracted from $5x$ and is done in the same way that the first arithmetic example is done. We take away x and we take away 2 and we have

$$5x-x-2=6.$$

In the second equation 2 less than x is to be subtracted from $5x$. If we subtract x we have subtracted too much just as in the arithmetic example we subtract too much when we subtracted 20. So we shall have to add 2 to x just as we added 2 to 20. Then we shall have

$$5x-x+2=6.$$

Now we can finish the solutions without further difficulty. This method is the natural and practical way of oral arithmetic and should make a strong appeal to the student's reasoning. If he does not see the why of it readily, keep him on the arithmetic of it until he does.

Now suppose we have the situation

$$7x-2(x+2)=6.$$

This means to subtract twice the quantity $(x+2)$ from $7x$. We may double the quantity $(x+2)$ first and then subtract obtaining

$$5x-(2x+4)=6.$$

Which then may be solved as in the previous situation.

In the equation

$$5x-2(x-2)=10$$

we have twice the quantity $(x-2)$ to be subtracted from $5x$. Let us first double the quantity to be subtracted and then we shall have

$$5x-(2x-4)=10.$$

Then we continue the solution as we have learned above. As this added feature of subtraction becomes more familiar to the pupil he will of his own accord in many cases take the two steps in one. The teacher will see that all do likewise as soon as they are able. Incidentally the pupil has learned to multiply two negative numbers together. He does not need to know anything about signed numbers and the algebraic scale as yet, however, for he has dealt thus far only with signs of operation and positive results.

Before introducing the student to signed numbers, we might give him some work in the graph of statistics and of the formula involving positive quantities only. From such work he can then pass easily to a graphic representation of signed numbers, for example a temperature chart representing thermometer readings for several successive hours.

TEMPERATURE GRAPH

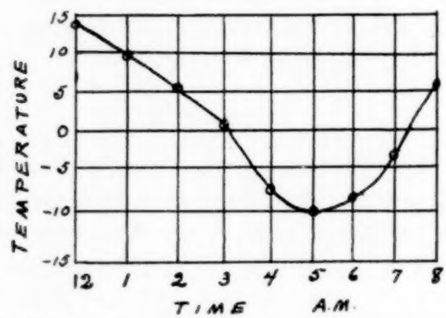


FIG. 1. Graph showing the variation of temperature with time Friday morning, February 23, 1934.

As we construct this graph we shall have to distinguish between readings above 0 and readings below 0. We can do so by calling those above positive or plus and those below negative or minus. The pupil will notice that both sets of numbers begin at 0. The sign of the number depends upon the direction it takes, hence signed numbers or directed numbers. The pupil now has before him the algebraic scale developed through a meaningful exercise.

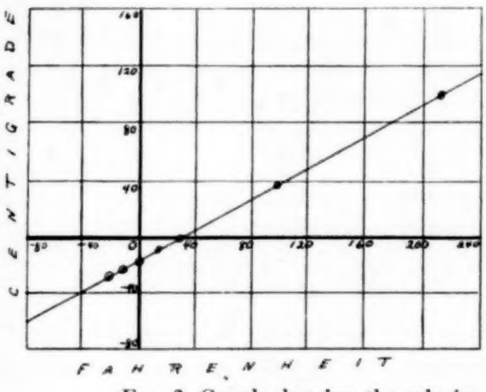
Another such formula which will lead to meaningful negative values is

$$v = 200 - 32t$$

which gives the velocity after t seconds of a projectile thrown upward with an initial velocity of 200 ft. per second. For instance, when $t=7$, $v=-24$ which means that the projectile has already reached its maximum height and is returning with a velocity of 24 ft. per second in a downward direction.

Having learned to plot the graph of the formula with positive values for the independent variable, the pupil is now ready to plot using negative values. An excellent formula for this purpose is the one which shows the relation between centigrade and Fahrenheit readings.

In plotting this graph the student will learn that both values of the variables may be positive and that either one or both may be negative. He will see, too, that the number scale may run both vertically and horizontally. In evaluating C when $(F-32)$ is negative, the student will learn the graphic meaning of subtracting a larger number from a smaller number. For instance, when $F=14$, $C=5/9(14-32)$ and when $F=-13$,



F	C
212	100
100	37 7/9
32	0
14	−10
0	−17 7/9
−10	−23 1/3
−13	−25

FIG. 2. Graph showing the relation of Centigrade to Fahrenheit temperature.

$C=5/9(-13-32)$ which are two different types of situations. In the first situation we are to subtract 32 from 14 and then take 5/9 of that result. Let us see what this means on the number scale. Find $C=14$, now count down 32 spaces and arrive at -18. Now take 5/9 of -18 and obtain -10. Notice that -32 is a sign of operation and that -10 is a sign of position on the number scale. Similarly, in evaluating C in the second case, find $F=-13$, count 32 spaces down and arrive at -45. 5/9 of this result gives us -25. In both of these situations the pupil has learned incidentally to multiply a negative number by a positive number, as 5/9 of -18 and 5/9 of -45.

To illustrate the further use of signed numbers and their manipulation, we may give the pupil equations leading to negative answers as for example, $x+5=2$, etc., to more difficult ones.

Now that the pupil is familiar with signed numbers on two sets of axes and knows that the unknown quantity may be positive as well as negative, he is ready to solve graphically simultaneous equations in two unknowns. Since there are no new ideas involved in the subtraction process in the graphic solution, we shall pass on to the consideration of the solution of such

equations by subtraction. Here is, no doubt, the first place where we need to consider vertical subtraction and it seems best to let drill exercises precede the application. We may, however, give the pupil equations to solve by addition before.

As we analyze the subtraction process, we shall find several types of situations, some already familiar and some not. If the pupil thinks of vertical subtraction as finding the difference between two signed numbers, he will not have much difficulty. It is well to begin with the simplest cases and extend the work over a period of several days. The following analysis may prove helpful in grading the exercises according to difficulty.

TYPES OF SITUATIONS

I. When both numbers are positive.

a. When subtrahend is smaller than minuend.

$$\begin{array}{r} 8 \\ \underline{6} \\ 2 \end{array} \quad \text{Check: (Mentally) } 2+6=8$$

This, of course, is the already familiar arithmetic situation.

b. When subtrahend is larger than minuend.

$$\begin{array}{r} 6 \\ \underline{8} \\ -2 \end{array} \quad \text{Check: } -2+8=6$$

If we look on the number scale, we shall find that there is a difference of 2 spaces between 6 and 8. Since we are subtracting 8 from 6 instead of 6 from 8, the difference will be negative for the subtrahend is larger than the minuend. We might think also of subtracting in the reverse order from example I.a.

Looking at this situation from the viewpoint of arithmetic, we might consider that 8 from 6 gives us a shortage of 2, hence -2. We may also think: what number added to 8 gives 6? -2, for $8-2=6$. If the pupil has had additive subtraction, this method proves to be quite natural. It is advisable to teach all viewpoints as the pupil is more likely to understand and appreciate any such situation better if he sees it from more than one angle.

II. When both numbers are negative.

a. When subtrahend is smaller than minuend.

$$\begin{array}{r} -2 \\ \underline{-4} \\ 2 \end{array} \quad \text{Check: } 2-4=-2$$

On the number scale we see that there is a difference of 2 between -2 and -4. The sign is positive since we are subtracting a smaller number from a larger number. We may think also: $-4+?=-2$.

b. When subtrahend is larger than minuend.

$$\begin{array}{r} -4 \\ \underline{-2} \\ -2 \end{array} \quad \text{Check: } -2-2=-4$$

Graphically there is a difference of 2 as before but the subtraction is in the reverse order, hence the result is negative or subtracting a smaller number from a larger number gives a negative result. Additively, $-2+? = -4$.

III. When one number is positive and the other negative.

a. When subtrahend is negative and minuend is positive.

$$\begin{array}{r} +3 \\ -2 \\ \hline +5 \end{array} \quad \text{Check: } 5-2=3$$

On the number scale there are 5 spaces between $+3$ and -2. We are subtracting a smaller number from a larger, or in the natural order, hence the result is positive. Or, $-2+? = +3$.

b. When subtrahend is positive and minuend is negative.

$$\begin{array}{r} -2 \\ +3 \\ \hline -5 \end{array} \quad \text{Check: } -5+3=-2$$

Here the difference graphically is 5 as before but we are subtracting in a negative order or subtracting a larger number from a smaller. Hence, a negative result. Or, $3+? = -2$.

We can readily see from this analysis that the subtraction process is by no means a simple one. Its complete comprehension is, therefore, not a matter of a few days. Rather it is the task of the teacher to present each new phase only as rapidly as the pupil can assimilate it. The drill work in vertical subtraction may be varied by giving the pupil miscellaneous types of situations along with the new phase and by stating the exercises in different ways to show the relation between vertical and horizontal subtraction. For example: From $+5$ take -2 or $+5-(-2)=?$ Notice that in the second example the first minus sign is one of operation and is the shorthand for *subtract* or *take away*; the second is one of quality or position.

After sufficient drill work the pupil will be ready to solve simultaneous equations by subtraction.

For example:

$$\begin{array}{ll} 2x-4y=0 & \qquad 3x+2y=8 \\ 2x-3y=1 & \qquad 3x-\ \ y=5. \end{array}$$

Notice that the equations themselves contain only signs of operation but that in solving we treat them as abstractions. For instance, the difference between a $4y$ that has been subtracted and a $3y$ subtracted is the same as finding the difference between a $-4y$ and a $-3y$ on the number scale. Similarly, in the second equation the difference between a 2y that has been added and a y that has been subtracted is the same as finding the difference

between a $+2y$ and a $-y$ on the number scale. The pupil is now ready to apply vertical subtraction in long division, also.

In this discussion I have endeavored to show the subtleties of the subtraction process and to urge that it be given a more natural growth over a longer period of time and that it be presented in its various aspects as the needs of a rational algebra require.

THE SOCIALIZATION OF HIGH SCHOOL PHYSICS

By R. B. DeLano

Memorial High School, Boston, Massachusetts

While high school physics is decidedly popular with boys an investigation will show that there are few girls taking this most important subject. In fact, most schools make no attempt to teach physics to girls. Since no subject in the secondary course of study touches the pupil's life more closely than elementary physics, it is evident that this condition should not exist.

I once asked a girl in my college preparatory class why she was not more interested in the subject and her reply was that she saw practically no reason for learning many of the facts regarding which instruction was given. After giving the matter careful consideration, I came to the conclusion that she was right. The course as now given in most schools is not adapted to the needs of the average student.

I have before me the last College Entrance Examination Board paper. The subjects in the order of examination are kinetic energy, frequency, wave length, virtual images, acceleration of gravity, theory of heat, index of refraction etc. Add to this the required knowledge of dynes, ergs, poundals etc. and you have a mass of knowledge which might be of value to the research student but which is of little value in everyday life.

Although some teachers give what they call a practical course, the average college graduate teaches physics in the high school as it was taught to him in college. The course given is, therefore, ecbatic rather than telic. It gives the student little knowledge of his milieu. It is a serious mistake to place in the hands of the average commercial or non-college student a text of the type usually written by a college instructor.

About five years ago, I introduced a course in physics which was organized on the basis of the social needs of the average high school student.[1] This course started with a class of 15 students. This year over two hundred girls *elected* the course.

In this course I have attempted to teach the subject inductively rather than deductively. The student sees the need of the knowledge before she is asked to learn the law. The recitation is socialized. Discussions are held. Imaginary trips with the stereoptican are taken to many places where it would be impossible to take the class as a whole.

Our study of the automobile begins with the steering wheel, the emergency brake and the indicators on the instrument board. The study of pressure and water systems begins with the faucet at the kitchen sink. Our study of electricity starts with the alternating current and the lamp socket.

Girls who have taken the course know what to do when an emergency arises in the home. They can operate any type of heating system and know how to use the modern appliances which lighten labor. They understand what happens when they turn the dials of the radio. They can drive an automobile intelligently which is an impossible feat for one who has no knowledge of the laws of physics. They are, in fact, fitted to live in a world where scientific knowledge touches our lives on every hand, modifying our environment and disrupting our daily habits.

[1] See *Applied Electricity for High School Students*, by R. B. DeLano. This book is published by D. C. Heath & Co.

NEW INSTRUMENT MEASURES HEAT OF BODY WITHOUT TOUCHING SKIN

A new device for measuring the temperature of the surface of the body and also the amount of heat radiating from the body was shown at the meeting of the American Institute of Nutrition by Dr. James B. Hardy of the Russell Sage Institute of Pathology and Cornell University Medical School. Such measurements have been made before by means of thermocouples applied directly to the skin. Dr. Hardy's method seems to be easier to use. He does not even touch the skin to take its temperature, and can measure temperature through the clothing as well as on bare skin. By this new device Dr. Hardy was able to determine how much heat the body loses through perspiration, for example, and from what surfaces the heat is being lost. He can also watch how the body adjusts its temperature as the temperature of the room goes up.

—*Science Service.*

CHANGING TRENDS IN TEACHING CHEMISTRY*

By Wilhelm Segerblom
Phillips Exeter Academy, Exeter, New Hampshire

The data given in this paper are based not on personal opinion but on the writer's connection with various committees and organizations which have been studying the problems of the teacher of chemistry.

A decided swing is evident from excess laboratory work to a more sane balance between class room and laboratory work. Before 1870 elementary chemistry was usually taught without laboratory work. During the following decades when the colleges dominated the teaching of chemistry in the secondary schools laboratory work flourished, and in some cases was much overdone. During the last twenty years the ratio of laboratory work has swung back to a more normal balance.

The college Entrance Examination Board and the Division of Chemical Education of the American Chemical Society have clarified the content of the high school course. The former agency wields a strong hand in determining what shall be taught in high school chemistry. Many texts and state outlines were studied in drawing up its syllabus, and the ninety per cent of high school pupils who do not go to college were taken into account. The latter agency looked at chemistry not as a college entrance subject but as a study for non-college students primarily though the Division's committee tied its outline up with that of the College Board.

Various states have developed helpful chemistry outlines. These differ widely from a small minimum to a very full and detailed outline. Some of them are inclined to stress local conditions.

Methods are being studied by organizations of teachers. Reports of these investigations have been published as follows: those by the Central Association of Science and Mathematics Teachers in School Science and Mathematics, those by the New England Association of Chemistry Teachers in its own printed reports, and those by the Division of Chemical Education in the *Journal of Chemical Education*.

More schools are fitting their courses to the needs of the pupils, resulting in two distinct types of texts. This occurs

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* Presented before Section Q (Education) of the American Association for the Advancement of Science at the Boston Meeting December 1933.

generally in states where the College Board's influence is less dominant. These texts usually emphasize household chemistry, every-day chemistry and so-called practical chemistry. Such texts have appeared in both the Atlantic and Pacific regions as well as from the middle states.

Methods of evaluating texts are being improved. Less stress is being laid on the physical makeup of the book and more on the logical presentation and teachableness of the subject matter. The proportion of texts written by high school teachers is increasing.

The unit system of instruction is being developed. This tends to bring out relationships between topics better and gets away from the condensed encyclopedia type of text.

A new movement is trying to replace student experimentation with teacher demonstration. Opinion seems to favor a judicious combination of individual experimentation and teacher demonstration. The latter used alone has several drawbacks, and may on the surface savor of the type of instruction used before 1870. It has one advantage, viz: it is less expensive in regard to chemicals and apparatus, but this is fraught with the great danger that school boards may advocate its greater use, not because of its inherent advantages but for financial reasons only with a probable detriment to effective teaching.

Visual education is coming forward with numerous aids. Many of these are of great assistance.

The new so-called "Workbook" is being pushed as a substitute for the former laboratory manual. This is a combination of directions for laboratory experiments, questions and problems usually found at the ends of chapters in the text, drill exercises, and devices for helping the student correlate his ideas.

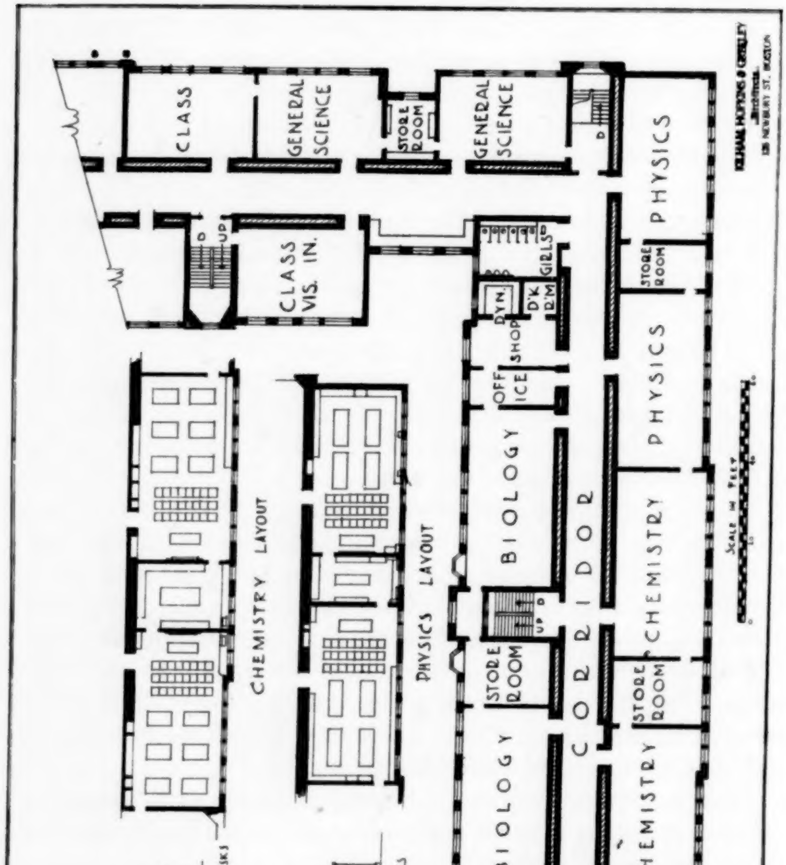
Inclusion of the newest theoretical concepts into the high school course has its proponents and opponents. A limited amount is desirable but it can easily be overdone at the expense of the more important basic principles.

Finally, that chemistry is being linked up with the other sciences more than ever is self-evident and should work out to a better rounded education.

Every minute of the year there is an average of 1,800 thunder storms going on somewhere in the world. There is an average of 300,000 lightning flashes an hour throughout the world.

A LABORATORY SUITE

Compact, economical, conveniently arranged, and highly practical, is the suite of rooms known as the *John C. Packard Laboratories* of the Brookline (Mass.) High School recently completed and named after their designer, the veteran Dean of the Faculty and Head of the Science Department. The outfit consists of eight laboratories, two for General Science, two for Biology, two for Physics, and two for Chemistry—arranged in



pairs, with a well equipped apparatus room of generous proportions between each pair—an office for the Head of the Department, a workshop, a dark room, a dynamo room, and a visual instruction room fitted up with the latest devices for the projection of movies, lantern slides, and opaque pictures of every description. The workshop contains a lathe, an upright drill, an emery wheel, a jig saw, a circular saw—each driven by an independent motor—a carpenter's bench, an iron-worker's bench, a complete equipment of tools, and a built-in case for unfinished work. The dynamo room contains a motor-dynamo, consisting of a 2 K.W. motor with a direct connected dynamo attached at either end, for the supply of a variable (0 to 30 V.) D. C. current to the two Physical laboratories, and a compressed-air machine. The General Science laboratories are supplied by an independent unit (0 to 10 V.) installed in the Apparatus Room adjoining. Ingenious devices for the economical distribution of electricity—A.C. and D.C.— and compressed air, while meeting every need, helped to bring the cost down to a point quite within reason, even for these strenuous times. The floor plan is shown in the illustration.

The rooms are adapted for twenty-four pupils to a section (thirty-five in general science). Each room a combination of lecture room and laboratory with cases at the side of the room for apparatus, notebooks, and a wardrobe, make the conditions fairly ideal. The tops of the chemistry tables are of alberine stone, the rest are of birch, treated with acid-resisting finish and stained brown. The biology section is fitted up with cages for small animals, cabinets for charts, and sundry aquaria. Two bay windows, filled with plants, help to give a home-like appearance to the Biology rooms, while a number of display cases in the corridor, ivory-white on the inside and lighted by concealed electric lamps, for the exhibit of birds, minerals, butterflies, and unusual bits of apparatus, render the approaches to the suite most attractive.

A CRITICAL EVALUATION OF REVIEW

By Carleton A. Moose
Milne High School, Albany, New York

The purpose of this experiment was three-fold. (1) To discover the immediate values resulting from four review lessons in biology. (2) To discover how much of the knowledge gained in the review process was retained after a delay of ten weeks and (3) to find out what type of student profited most by the review, the poor, the average or the very good.

The fifty-two ninth grade children whose results furnish the data for this article were instructed in elementary biology for the first term of the present school year. One week before the end of the term a comprehensive examination covering the work of the entire term was given. The students had no idea that the test was to be given and hence had made no especial attempts to prepare for it.

The type of test given can best be described as an objective "power" examination made up of selective judgment, completion, and matching questions. This fact made possible very accurate scoring and provided an examination that tested not only knowledge of subject matter but the ability to make practical use of what had been learned. Samples of the questions follow.

1. Select from the following expressions the one that is most closely related to each of the terms in column 1 and write the expressions in column 2 opposite the corresponding term: ovule, osmosis, roots, sap ducts, chlorophyl, bark, monocot, insects, pappus, transpiration.

Column 1	Column 2
1. stems	....
2. protection	....
3. pollen grain	....
4. cross-pollination	....
5. seed dispersal	....
6. root hair	....
7. stomata	....
8. corn grain	....
9. starch	....
10. geotropism	....

2. In the parenthesis at the right of each word in column B write the number of the word in column A that is most closely related to it.

Column A	Column B	
1. osmosis	poppy	( )
2. transpiration	stamen	( )
3. ovules	root hairs	( )
4. sepals	feathery pappus	( )
5. opium	pistil	( )

6. rubber	explosive capsules	( )
7. flax	evaporation	( )
8. petals	rayon	( )
9. witch hazel	linen	( )
10. dandelion	winged fruit	( )
11. nucleus		
12. pollen		
13. maple		
14. wood pulp		

3. Underline the word or expression that makes the statement true:

(a) The male reproductive cell is called the ovum, sepal, ovule, anther, sperm, pistil.
(b) A collection of similar cells is called a tissue, organism, organ, larva, embryo.
(c) The stage in the development of an insect which immediately follows fertilization is the adult, pupa, cocoon, egg, larva.
(d) A collection of tissues specialized for a definite function is called organism, cell, larva, tissue, organ.
(e) The tissue that must be united in grafting is the epidermis, cortex, cambium, phloem, xylem.
(f) The apple worm is the larva of the boll weevil, tsetse fly, codling moth, tussock moth, ladybird beetle.
(g) A flower which is usually wind pollinated is the rose, fern, corn, water lily, violet.
(h) The sepals of a flower taken together are called the receptacle, corolla, stamens, calyx, carpels, petiole.
(i) Mandibles are a kind of fins, swimming organs, gills, breathing pores, mouth parts, antennae.
(j) The turning of plants toward the light is called heliotropism, geotropism, photosynthesis.

4. In front of each illustration below write the letter (A, B, C, D, E) of the statement of fact that is most closely related to it.

Statements of Fact

A. Plants need sunlight to perform photosynthesis.
B. Plants release oxygen during photosynthesis.
C. Green leaves manufacture food.
D. Carbohydrates manufactured during photosynthesis are stored in insoluble form.
E. Plants obtain CO_2 for photosynthesis through the stomata.

Illustrations

.... 1. An aquarium that contains a large number of growing plants requires little or no care.
.... 2. In sections of the country where much soft coal is used the plants do not thrive well.
.... 3. The lower leaves of plants often have longer petioles than the upper ones.
.... 4. Washing the leaves of a house plant aids its growth.
.... 5. Forest trees are much taller than those in the open.
.... 6. Plants growing in an atmosphere lacking oxygen live longer in a light place than in a dark place.
.... 7. Parsnips are not so sweet in winter as in spring.

.... 8. A geranium with white leaves could not live.
.... 9. Germinating seeds contain more sugar than ungerminated seeds.
.... 10. Potato beetles affect the size of the potato crop.

The range of scores was from 46 to 88 on the basis of 100 and they were classed in groups as shown in column 1 of the accompanying table. The number of scores in each group is indicated in column 2. The average of each group on the basis of 100 appears in column 3.

The four review lessons which followed immediately included first a study based on the errors made on the preliminary examination and then a general drill on the major concepts which had been taught during the first semester.

TABLE I

Scores	No. pupils	Average score before review	Average score after review	Average score after 10 weeks interval	Gain of col. 4 over col. 3	Gain of col. 5 over col. 3	Percent of gain retained
col. 1	2	3	4	5	6	7	8
40–49	7	43.5	74.1	67.0	30.6	23.5	76%
50–59	10	55.3	76.2	69.3	20.9	14.0	67%
60–69	12	65.3	86.3	76.2	21.0	10.9	52%
70–79	10	74.0	90.7	86.8	16.7	12.8	77%
80–89	13	84.3	93.4	91.1	9.1	6.8	75%

The midyear examination which was given the following week was made up of two parts each marked on the basis of 100 with one part the same examination that had been given as the preliminary. Column 4 of the table shows the averages in the final examination of those children originally classed as in column 1, and column 6 gives the gain of the second test over the first. As would be expected the lowest group had made the greatest gain while the highest group had made the least.

It is interesting to compare the results of the two tests and observe that the average on the first test of 29 students of the 52 was below the passing mark of 70, while on the second application of the test the average of the lowest group was 4 points above the failing mark. The review resulted in increases in grades of from 9.1 for the highest group to 30.6 for the lowest group which gave 23 children an honor average in the final and brought the 29 failing students above 70. The practice effect could not account for such an increase.

During the first ten weeks of the second semester work was carried on as usual in fields which were entirely different from

those considered in the first semester. The children did not know the results of the second test nor was anything said which would lead them to believe that they were to be retested on the first semester material.

The third test was given after a delay of ten weeks and column 5 shows the averages of the original grouping. Column 7 contains the gain of the third test over the first, while column 8 shows the percentage of the gain of the second test over the first test which the children have retained after the delay. It will be seen that again the lowest group retained the greatest amount and the highest group retained the least, but the percentages of gain retained after the delay are very similar in three of the groups with the other two groups retaining considerably less. There seems to be no way to account for the lower retention of the second and third groups.

Conclusions which can be drawn from observation of the data are:

1. The immediate value of a review of a semester's work is greater for the poorer students than for the better ones. In fact in some cases a review might be a waste of time for some of the better students.
2. From 52% to 77% of the knowledge gained by means of the review was retained at the end of ten weeks.
3. After ten weeks delay fourteen had fallen below a passing average of 70 against twenty-nine who failed the first test.
4. The results of this small study show that on the whole review procedures are valuable mainly in enabling children to pass an examination since in the short period of ten weeks from 23% to 48% of the material gained by review had been lost. How much more would have been lost at the end of ten months or two years?

SOUND AND LIGHT

Two excellent booklets for supplementary reading in general science and physics are the Cornell Rural School Leaflet for January 1933 on Light and the issue for January 1934 on Sound. All the important elementary principles of these two topics are illustrated by devices and, stunts that a child can grasp. Interesting phenomena to be observed, simple experiments for individual or group project work, optical illusions, and many other features to develop observation and stimulate study are included. These Leaflets may be obtained for a small sum by writing Cornell Rural School Leaflet, Cornell University, Ithaca, N. Y.

A SIMPLE MICRO-PROJECTOR

By John R. Harris
Botany Student Assistant, Shortridge High School, Indianapolis, Indiana

The December, 1932, number of School Science and Mathematics contained an article by E. W. Bossing on the "Value of Micro-projectors in the Teaching of Biology" which made the Botany teachers of Shortridge High School eager to own a good projector. No funds being available for purchasing one, we set to work to make it. The resulting device worked so well and is so simple, that we are sending in a description of it. The only materials needed are, a microscope, a strong light, and a smooth, light place on which to project the image.

The advantages of the micro-projector are well understood. By its use time and effort are saved and the whole class may simultaneously view a slide, making it possible for the instructor to point out subjects under consideration. It more definitely fixes salient points in the student's mind, and is invaluable for review.

This simplified micro-projector may be quickly assembled by removing the eye-piece and the draw tube from the tube of the microscope, and tilting the microscope back to a horizontal position, with the open end of the tube pointing toward the screen. A strong light, such as a stereoptican, or a projection lantern, or whatever may be available, should be placed at right angles with the microscope, and the light reflected into the microscope by the mirror. A beam of parallel rays is necessary for the best results. If the available light throws diverging rays, this may be remedied by removing the front lens of the lantern. Any white or light colored smooth surface may be used for the screen. It is a good plan to project the light into a dark corner of the room or to partially darken the room, although good results may be obtained with the usual light.

If living specimens, such as protozoa or algae, are to be shown, the microscope may be left upright and the image thrown upon the ceiling, which will serve as a good screen. Water should be added from time to time, to keep the specimens from drying out.

If the ceiling is too high, a heavy piece of beaver board covered with white paper may be suspended like a picture at any desired angle with the wall as a screen for the projection.

This may be arranged by bracing the bottom against the upper blackboard molding and drawing a long cord that corresponds to the picture-wire, through a ring attached to a picture hook on the picture molding. This suspending cord may be drawn up tight so that the screen lies flat against the wall when not in use.

The equipment used in the Shortridge High School laboratory consisted of a three-power microscope (×40, ×100, ×250) and a projection lantern, with the front lens removed. A folded piece of white cardboard, two feet by three feet, served as a screen. One-half of this card board, forming a right angle with the screen, was placed parallel with the windows in order to cut out some of the outside light.

Excellent results were obtained. The projected slides were greatly magnified with all colors true to the original. For instance, on a screen 4 feet from the projector, using the ×40 objective, a cross section of a fern rhizome was 12 inches in diameter. Every cell was clearly defined and the image was visible over the entire room. When the ×100 objective was used, on the same screen at the same distance, the image was so large that only a part of the section showed. The xylem cells in the fibrovascular bundles measured three-quarters of an inch in diameter. When using the ×250 objective these same cells became about 2 inches in diameter. This latter projection is somewhat less clear than the others due to the short focal length of the lenses.

Caution must be used in operating the projector. Due to the heat caused by the intense light necessary, the balsam in the prepared slides is apt to melt if allowed to become hot. By feeling the slide it is easy to tell when this temperature is reached. If too warm, the light should be turned off, and the slide given time to cool. For this reason, for magnifications up to ×100, the plain side of the mirror should be used. Owing to the necessity for strong light, when using ×250 or higher, the curved side of the mirror must be used and consequently the heat rays will be concentrated, causing the slide to heat more quickly. This condition will necessitate frequent cooling. Experience will soon teach the operator how to handle the projector.

The gulf stream is the great hot water heating system of the North Atlantic. If it should lose ten degrees of heat ice-age conditions would soon return to northern Europe.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1321. *Maxwell O. Reade, Brooklyn, N. Y.; David Gordon, Woodbine, N. J.; Charles W. Trigg, Los Angeles, Calif.*
1320. *David Gordon, Woodbine, N. J.*
1316, 1318, 1319. *David Gordon, Woodbine, N. J.*
1317. *C. W. Trigg, Los Angeles, Calif.*
1322. *Proposed by W. E. Buker, Leetsdale, Pa.*

Prove that the area of a quadrilateral with given sides is a maximum when it is inscriptible.

First Solution: Solution by Proposer

If the sides of a quadrilateral are a, b, d, c and A and C are opposite angles, it is known that (s-d)

$(\text{Area})^2=(s-a)(s-b)(s-c)-abcd\cos^2 \frac{1}{2}(A+C)$, where s is the half sum of the sides. From this it follows immediately that the area is a maximum when $A+C=180°$.

Second Solution: Solution by Roy MacKay, Albuquerque, N. M.

Let $ABCD$ be a quadrilateral with sides AB, BC, CD, and DA equal. respectively to x, y, z, and w. Denote the area of this quadrilateral by q. Since the area of a triangle is given by half the product of two sides and the sine of the included angle,

$$2q=wx\sin A+yz\sin C.$$

For q to be a maximum, $dq/dA=0$. That is

$$wx\cos A+yz\cos C\, dC/dA=0. \tag{1}$$

Now dC/dA can be obtained from the two expressions for the square of the diagonal DB, namely:

$$w^2+x^2-2wx\cos A=y^2+z^2-2yz\cos C.$$

That is $2wx\sin A=2yz\sin C\,dC/dA$, or

$$dC/dA=wx\sin A/yz\sin C.$$

Substituting this in (1) and simplifying, there results:

$$\sin(A+C)=0.$$

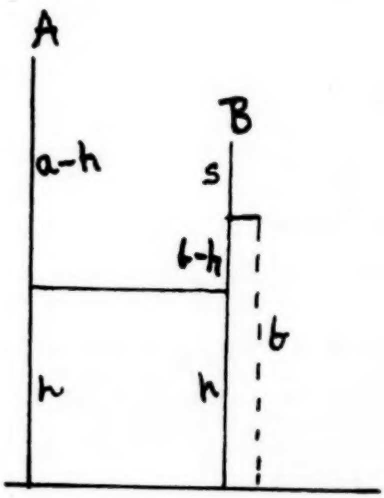
It follows that for a maximum area, opposite angles are supplementary and thus the quadrilateral is cyclic.

EDITOR'S NOTE: Aaron Buchman, Brooklyn, N. Y., in his solution, observes that if A or C approaches zero then C or A respectively approaches 180° in which case a minimum results for the area.

Also solved by John E. Bellardo, St. Nazianz, Wis., and Charles W. Trigg, Los Angeles.

1323. *Charles P. Louthan, Columbus, Ohio.*

Two parachute jumpers, A and B leap from their airplanes at the same instant. A is a feet and B is n feet $(a>n)$ above the ground. Assuming that that the air resistance before the parachutes open is negligible and after their parachutes are open, they drop at a uniform rate of r feet per second, determine the altitude at which A's parachute must open so that both reach the ground simultaneously.



Solution by the Proposer.

Assume that B's parachute opens after falling a distance of s feet in t seconds. Let $b=n-s$, and let h be the altitude in feet at which A's parachute must open. The time required for A to reach the height h, is $\sqrt{\dfrac{2(a-h)}{g}}$. The time required for B to reach this height is $t+\dfrac{b-h}{r}$.

Since the time required for A and B to reach the height h, is the same, we obtain the equation:

$$(1) \qquad t+\frac{b-h}{r}=\sqrt{\frac{2(a-h)}{g}}$$

which reduces to

$$(2) \qquad h=\left[g(b+rt)-r^2\pm r\sqrt{2g(a-b-rt)+r^2}\right]/g.$$

EDITOR'S NOTE: This solution assumes that t is known. If $t=0$, Roy MacKay, Albuquerque, N. M., Richard Raymond and Jay Jordan, Spokane, Washington give the solution as follows:

$$h=\frac{n-r^2\pm\sqrt{r^2-64n+64a}}{g}.$$

If t is unknown, the solution to the problem as indicated by W. E. Buker, Leetsdale, Pa. is indeterminate.

Also solved by Charles W. Trigg, Los Angeles, Calif.

1324. *Proposed by Clyde Rosser, Gaston, Ore.*

If two tangents are drawn to a circle from an external point, then the distance from any point on the minor arc to a chord of contact is the mean proportional between the distances to the two tangents from the same point.

EDITOR'S NOTE: When this problem was submitted it was not observed that it had previously been solved in the May 1933 issue of this magazine.

Solutions also were offered by: Boris Garfinkel, Buffalo, N. Y.; Cecil B. Read, Wichita, Kan.; Aaron Buchman, Brooklyn, N. Y.; Roy MacKay, Albuquerque, N. M.; and the proposer.

1325. *Proposed by A. Wand, Glendale, Missouri.*

Bisect the area of any quadrilateral by a line passing through a given point in one of its sides.

Solution by F. A. Cadwell, St. Paul, Minn.

CASE 1.

Let $ABCD$ be the quadrilateral and P a point on AB. Draw PC and PD. From A and B draw parallels to PD and PC respectively, meeting CD at E and F.

Draw PE intersecting AD in L and PF interesecting BC in M. Find G, the mid-point of EF and draw PG intersecting AD in H. On HA take K so that HK shall be the 4th proportional to PH, HD and HG, and draw PK. Then PK bisects the area of $ABCD$.

PROOF: Since AE is parallel to PD, $\triangle PAD=\triangle PDE$.

Similarly $\triangle PBC=\triangle PCF$.

Then $ABCD=\triangle PCD+\triangle PDE+\triangle PCF=\triangle PEF$.

Because G is the mid-point of EF

$\triangle PGF=\frac{1}{2}\triangle PEF=\frac{1}{2}ABCD$.

Taking from the equal triangles PBC and PCF the common triangle PMC leaves $\triangle PMB=\triangle CMF$. $\therefore \triangle PGF=\triangle PGF-\triangle CMF+\triangle PMB$ $=PBCG=\frac{1}{2}ABCD$.

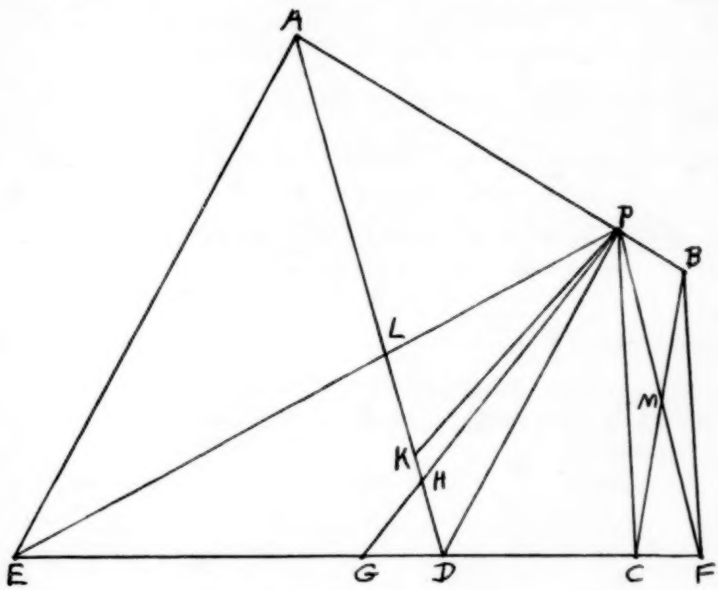
HK by construction, is the fourth proportional to PH, HD and HG.

$\therefore PH\times HK=HG\times HD$. $\therefore \triangle PHK=\triangle HDG$.

$\therefore PBCG=PBCG-\triangle HDG+\triangle PHK=PBCDK=\frac{1}{2}ABCD$.

$\therefore PK$ bisects $ABCD$.

CASE 2. If G coincides with D or C, or if G lies between C and D, then PG will bisect $ABCD$ as it is shown above that Quad. $PBCG = \frac{1}{2}ABCD$.



1326. *Proposed by a reader.*

If the sides of a triangle are in arithemetic progression, having a common difference of one, find the sides and angles if the largest angle is double the smallest.

Solution by Boris Garfinkel, Buffalo, N.Y.

With a suitable unit of length we may express the three sides numerically as x, $x+1$, $x+2$. Denote the opposite angles by θ, $180° - 3\theta$, 2θ respectively. By the law of sines:

$$\begin{cases} \dfrac{x+2}{x} = \dfrac{\sin 2\theta}{\sin \theta} & (1) \\[2ex] \dfrac{x+1}{x} = \dfrac{\sin 3\theta}{\sin \theta} & (2) \end{cases}$$

Replacing $\sin 2\theta$ by $2 \sin \theta \cos \theta$ and
$\sin 3\theta$ by $3 \sin \theta - 4 \sin^3 \theta$
we find:

$$\frac{x+2}{x} = 2 \cos \theta \qquad (3)$$

$$\frac{x+1}{x} = 3 - 4 \sin^2 \qquad (4)$$

Eliminating θ from (3) and (4) gives the equation $x^2 - 3x - 4 = 0$ (5), whose positive root is $x = 4$. Hence the sides of the triangle are proportional to the numbers 4, 5, 6.

A trigonometric solution gives for the angles: 41°25′, 55°46′, 82°49′.

Also solved by Hobson M. Zerbe, Wilkes-Barre, Pa.; W. E. Buker, Leetsdale, Pa.; Roy MacKay Albuquerque, N.M.; B. Felix John, Pittsburgh, Pa.; J. O. Austin, Cowden, Ill.; Lester Dawson, Wichita, Kan.; O. K. DeFoe, St. Louis, Mo.; Charles W. Trigg, Los Angeles, Calif.

1327. *Proposed by G. W. Smith, Alta, Okla.*

Solve

$$x^2+y^2=13$$

$$x^3+y^3=35$$

Solved by O. K. DeFoe, St. Louis College of Pharmacy, St. Louis, Mo.

(1) $$x^2+y^2=13$$

(2) $$x^3+y^3=35$$

Factoring (2)

(3) $$(x+y)\ (x^2-xy+y^2)=35$$

Let $x+y=z$. Then making use of (1)
(3) becomes

(4) $$z(13-xy)=35$$

$$-xy=-13+\frac{35}{z}$$

(5) $$2xy=26-\frac{70}{z}.$$

Adding (1) and (5)

$$z^2=39-\frac{70.}{z}$$

(6) $$\therefore z^3-39z+70=0.$$

Factoring

(7) $$(z-5)\ (z-2)\ (z+7)=0$$

$$z=5,\ z=2,\ \text{and}\ z=-7.$$

Hence

(8) $$x+y=5.$$

Solving (1) and (8) by the usual method

$$x=3\ \ y=2\ \text{ or }\ x=2\ \ y=3$$

Similarly from

$$x+y=2 \text{ we get}$$

$$x=\frac{2+\sqrt{22}}{2}\ \text{and}\ y=\frac{2-\sqrt{22}}{2}$$

$$x=\frac{2-\sqrt{22}}{2}\ \text{and}\ y=\frac{2+\sqrt{22}}{2}$$

also from

$$x+y=-7 \text{ we get}$$

$$x=\frac{-7+23i}{2} \text{ and } y=\frac{-7-23i}{2}$$

$$x=\frac{-7-23i}{2} \text{ and } y=\frac{-7+23i}{2}.$$

Substituting these back in (1) and (2) all can be shown to be solutions.

Also solved by Charles W. Trigg, Los Angeles; O. K. DeFoe, St. Louis; Roy MacKay, Albuquerque, N.M.; Cecil B. Reed, Wichita, Kansas; Fern Corterville, Williamson, N.Y.; W. E. Buker, Leetsdale, Pa.; William W. Johnson, Cleveland, Ohio; John E. Bellards, St. Nazianz, Wisconsin; J. O. Austin, Cowden, Ill.; Maxwell O. Reade, Brooklyn, N.Y.

1285. (Renumbered **1283,** April 1933.) *Proposed by William H. Godson, Jr., Narberth, Pa.*

To construct a circle such that both tangents from a given point shall be 10 units in length, and the larger arc between the points of tangency shall also be 10 units in length.

Solved by Charles W. Trigg, Cumnock College, Los Angeles, Calif.

The problem of constructing an arc of a circle equal to a given straight line is the converse of a proposition, which if solvable would immediately lead to the "squaring of the circle." This problem consequently is not solvable with straight edge and compass. The following solution is one of several possible approximate ones.

Let y = radius of circle,

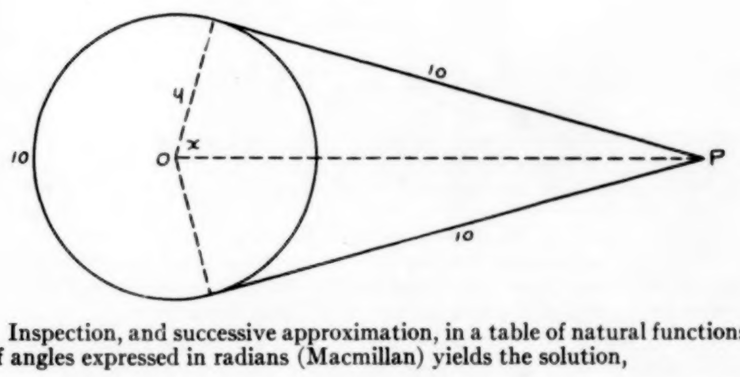
x = angle between radius to point of tangency and line joining center of circle to given point.

$y = 10/\tan x.$

$$\frac{2\pi-2x}{2\pi}\cdot 2\pi y=10.$$

$$y=\frac{10}{2(\pi-x)}.$$

$$\tan x=2(\pi-x).$$



Inspection, and successive approximation, in a table of natural functions of angles expressed in radians (Macmillan) yields the solution,

$$x = 1.304975 \text{ radians} = 74°46'15.4''.$$
$$y = 2.7224.$$
$$2(\pi - x)y = 10.000$$
$$\sqrt{100 + y^2} = 10.364.$$

With the given point as a center describe a circle with a radius of 10.364 units. With any point on this circle as a center describe a circle with radius of 2.7224 units, which will be the required circle.

1310. *Proposed by W. E. Buker, Box 66, Leetsdale, Pa.*

Find the length of the shortest and longest lines from the origin to the conic $ax^2 + 2hxy + by^2 = C$. Find also the direction of these lines.

Solved by Charles W. Trigg, Cumnock College, Los Angeles, Calif.

Since no first degree terms are present, the conic is central.

The distance, D, from the origin to any point, (x_1, y_1) along the line $y = mx$ will be $\sqrt{x_1^2 + y_1^2} = x_1\sqrt{1+m^2}$.

Solving $y = mx$ and $ax^2 + 2hxy + by^2 = C$ simultaneously,

$$x_1 = \pm\sqrt{\frac{C}{a + 2hm + bm^2}},$$

whence

$$D = \sqrt{\frac{C(1+m^2)}{a + 2hm + bm^2}}. \tag{1}$$

The slopes of the axes of the conic are determined by the relationship, $\tan 2\theta = 2h/a - b = 2 \tan\theta/1 - \tan^2\theta$. Solving for $\tan\theta$, the slopes are found to be:

$$m = \frac{b - a + \sqrt{(a-b)^2 + 4h^2}}{2h},$$

and

$$n = -\frac{1}{m} = \frac{b - a - \sqrt{(a-b)^2 + 4h^2}}{2h}.$$

Substituting these values for m in (1) and simplifying:

$$D_m = \sqrt{\frac{C(a + b - \sqrt{(a-b)^2 + 4h^2})}{2(ab - h^2)}},$$

$$D_n = \sqrt{\frac{C(a + b + \sqrt{(a-b)^2 + 4h^2})}{2(ab - h^2)}},$$

which are the distance from the origin to the conic along the axes.

Since no restrictions are placed on the nature of the constants, a, h, b and C, the problem will be discussed with reference to the discriminant, $4h^2 - 4ab$.

CASE I. $4(h^2 - ab) < 0$, and the conic is an ellipse.

Since the longest and shortest lines to an ellipse from its center are the major and minor semi-axes, respectively, the longest line equals D_n with the slope n, and the shortest line equals D_m with the slope m.

If $a = b$ and $h = 0$, then $D_m = D_n = \sqrt{C/a}$. That is, the ellipse is a circle with radius, $\sqrt{C/a}$, and the direction of the lines is indeterminate.

If $C=0$, the conic is a point ellipse, $D_m=D_n=0$.

If a and C have opposite signs, the ellipse is imaginary.

CASE II. $4(h^2-ab)>0$, and the conic is a hyperbola.

The shortest line to a hyperbola from its center is the transverse semi-axis, the longest line is the semi-asymptote $=\infty$.

Solving the equation for 4,

$$y=\frac{-2hx\pm\sqrt{4h^2x^2-4abx^2+4bC}}{2b}.$$

$$\frac{y}{x}=\frac{-h\pm\sqrt{h^2-ab+bC/x^2}}{b}.$$

$$\operatorname*{Limit}_{x\to\infty}\frac{y}{x}=\frac{-h\pm\sqrt{h^2-ab}}{b}.$$

which gives the slopes of the longest lines.

D_n is evidently imaginary. The length of the shortest line is D_m with slope m.

If $a=b=0$, the hyperbola is equilateral, so the coordinate axes are the asymptotes, with slopes of 0 and ∞.

If $C=0$, the conic is composed of two intersecting lines through the origin, and $D_m=0$.

CASE III. $4(h^2-ab)=0$. The conic is a degenerate parabola.

$$ax^2+2hxy+\frac{h^2y^2}{a}=C.$$

$$\left(x+\frac{hy}{a}-\sqrt{\frac{C}{a}}\right)\left(x+\frac{hy}{a}+\sqrt{\frac{C}{a}}\right)=0.$$

Hence, the degenerate parabola is composed of two parallel lines with slope $=-a/h=-h/b$.

The slope of the longest line is $-a/h$, $D=\infty$.

The slope of the shortest line is h/a,

$$D=\sqrt{\frac{aC}{a^2+h^2}}=\sqrt{\frac{bC}{b^2+h^2}}.$$

If $a=0$, then $h=0$, $D=\sqrt{C/b}$. If $b=0$, then $h=0$, $D=\sqrt{C/a}$. In either case, these shortest lines, and also the longest lines are coincident with the coordinate axes.

If $C=0$, the conic is a single line through the origin.

Evidently, a and b must have the same sign. If this sign is the opposite of that of C, the locus is imaginary.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1323. Jay Jordan and Richard Raymond, Lewis and Clark High School, Spokane, Washington.

1324, 1326. J. Hansen Smith, Battle Creek, Iowa.

1326. Daniel Shanks, Chicago.

PROBLEMS FOR SOLUTION

1340. *Proposed by Charles W. Trigg, Cumnock College, Los Angeles, Calif.*

Of all the right triangles circumscribed about a given circle, the isosceles right triangle has the minimum hypotenuse. Prove geometrically.

1341. *Proposed by Franklyn Olson, Wilmette, Ill.*

What is the locus of all points equally distant from a given circle and a point within the circle.

1342. *Proposed by a teacher.*

The area of a triangle is equal to one-fourth the square root of twice the sum of the products of the squares of the adjacent sides diminished by the sum of the fourth powers of the sides.

$\sqrt{2\Sigma a^2b^2 - \Sigma a^4}$

1343. *Proposed by Stanley Jashemski, Youngstown, Ohio.*

Given a balance and a number of weights whose total weight is N lbs. By various combinations of weights and by placing them on both scales it is possible to make any weighing consisting of a whole number of pounds between 1 lb. and N lbs. The problem is to determine the weight of every weight if it is known that the number of weights is the smallest possible under the conditions of the problem.

1344. *Proposed by Clyde Rosser, Gaston, Ore.*

The area of an inscribed regular polygon having an even number of sides is the mean proportional between the areas of regular inscribed and circumscribed polygons having half as many sides.

1345. *Proposed by D. Moody Bailey, Belsprings, Va.*

A triangle, ABC, with cevians AL, BM, and CN intersecting in S is given. Let lines be drawn from A, B and C, bisecting MN, NL and LM respectively. The three lines thus drawn are concurrent.

SCIENCE QUESTIONS

May, 1934

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio

Readers of School Science and Mathematics are asked to contribute: Questions, Answers, Comments, Suggestions—Whatever is new or interesting in the teaching of Science.

Wanted—Your examination papers and tests. Thanks! Mail them.—Do it now.

PUPILS AND GQRA

649—College Board—Entrance Examination in Physics

(published in April, 1934)

Please answer questions as follows—

Put answer to each question on a separate sheet of paper. Answers are desired from as many individuals as possible.

Part I—Questions 1, 2, 3, 4, 5, 6, 7. *Refer April, 1934.* SCHOOL SCIENCE AND MATHEMATICS.

Part II—Questions 8, 9, 10, 11, 12.

Names will be added to members of GQRA (Guild Question Raisers and Answerers)

STRAUSS SUGGESTS TESTS

653. *Biology Test by Samuel Strauss, Garfield High School, Akron, Ohio.*

"Science teachers have often been advised that they must test their pupils for their ability to apply principles of science to new, problematic situations. This is more easily said than done, for in actual practice, tests of this type are somewhat difficult to construct, particularly if it is also desired to make them objective and easy to score. Dr. Tyler of Ohio State University has found, as a result of experimentation, that the type of test that most satisfactorily answers these requirements is one in which a problematic situation is presented to the pupils, with a list of conclusions for them to check, and an additional list of reasons for the conclusions, also to be checked. Dr. Downing has also made use of this type of test.

If science teachers could get together and formulate tests of this kind and by using them in their classrooms, check and revise the tests, to improve them, there would be developed in the course of a few years a valuable and useful body of testing materials.

I should like to suggest that your department "Science Questions" in SCHOOL SCIENCE AND MATHEMATICS might excellently serve as the central clearing bureau for such a cooperative testing program for the high school sciences. Your department is read by many teachers all over the country who face the problem of developing practical, satisfactory tests for their classes. It would provide for them a central meeting place for the facile exchange of ideas.

I enclose several examples of the type of test described, which have been successfully used in the biology classes of our school. Your reaction to this suggestion will be much appreciated."

Please send your opinion of Mr. Strauss's suggestion. Also comment on the test that follows:

BIOLOGY TEST—PREHISTORIC ANIMAL

A party of explorers find the remains of a prehistoric animal. His bones are found near the bones of other animals, small and large. His skull is large, but the jaws are small. The front teeth in the lower jaw are wedge-shaped and the back teeth are large and broad, with the flat tops quite worn. The bones of the body are immense, and the neck very long. He must have been a very clumsy animal. On the front of his head he had two long, sharp horns.

One of the things the explorers try to determine is what the animal used for food. Check your own opinion below, placing an (X) in the parentheses after the correct answer.

1. He ate leaves and other plant food........................( )
2. He ate other animals..( )
3. He ate small animals and plants............................( )

The explorers should base their conclusions on:

1. A comparison of the prehistoric animal with animals living today..( )
2. A study of the structure of the animal......................( )

3. A comparison of the different bones found................. (   )
4. Samples of food found in the vicinity..................... (   )
5. Looking it up in an encyclopedia.......................... (   )

TRIAL QUESTIONS

Teachers in all science subjects—physics, chemistry, biology, geography, etc., are requested also to send in their "trial questions."

The questions in 643 "failed too many pupils." Why? They are republished below a few at a time, separately numbered. Please try them on your pupils and send in a good answer from each class; together, if possible, with the number of satisfactory and unsatisfactory answers. Comment is desired. What do your pupils say about them?

654—1. When a body displaces less than its own weight of liquid will it sink or float?

655—2. A 10-horsepower engine will do how much work in a minute?

656—3. Will an object weigh more or less in a vacuum than in air?

657—4. When a clock loses time should its pendulum be lengthened or shortened?

658—5. What is the mechanical advantage of a single movable pulley?

CHANGE OF STATE—A DIFFICULTY

659. *Proposed by David Gordon and Physics Class of Woodbine H. S., Woodbine, N. J.*

I noticed that one particularly difficult idea to get across to the students in my Physics class while studying 'Change of State' is the fact that solids can absorb heat during change of state without a change in temperature. The question I propose, then, is this:

(a) How can solids absorb so much heat at a fixed temperature without either changing temperature, or expanding or contracting?

(b) Why is it that the form of energy liberated during a change of state is heat energy, rather than light energy or some other form of energy? Could light energy effect a change of state?

I offer these questions on behalf of the Physics class at Woodbine High School.

Other Physics classes please send in answers. Get your name into the GQRA.

CHEMISTS ATTENTION

660. *Suggested by C. E. Waters through communication to Science, March 23, 1934, pp. 271–272.*

(a) What are the symbols for "deuterium"? "protium"? and "tritium"?

(b) What element might have been named, with equal logic, "copenhagenium"? and why?

(c) What element "newyorkium"? and why?

(d) What were the "eka-" elements of Mendelejeff finally named and why?

SOMETHING TO TALK ABOUT IN CLASS

661. *Suggested by an article in Cleveland Plain Dealer, Sunday April 1, 1934, "Its Long Story Big Advances."*

On an automobile

1. Mention the various "shock absorbers" (1904) as noticed (or unnoticed) by the rider on the back seat.
2. Is there any water in an "hydraulic" brake (1921)?
3. Why are the following great advances in auto manufacture?
(1) molybdenum steel (1921); (2) cobalt-chrome and high-tungsten steel for exhaust valves (1921); (3) silicon-chrome steel (1922); (4) lacquer finish (1923); (5) shaft drive(1901); (6) steering wheel (1904); (7) oil filter (1924); (8) placing radiator at front of engine (1903); (9) spring bumper (1906); (10) vibration damper for clutch (1924); (10) vibrator-type horn (1906); (11) magnetic-drag type of speedometer (1907); (12) spiral bevel final drive (1912); (13) Bendix drive for starting (1913); (14) vacuum fuel feed (1914); (15) aluminum alloy pistons (1915); (16) nickel-plating of radiator shells (1922); (17) chromium-plating (1927); (18) Warner four-speed internal gear transmission (1924); (19) magnetos (1905).

THE FLY AND THE BICYCLES

646. *Proposed by B. Felix John, Catholic High School, Pittsburgh, Pa.*

Once upon a time there was a stretch of road twenty miles long. At each end of this road was a bicyclist, and at exactly the same instant they started riding towards one another at a constant speed of ten miles an hour, continuing until their front wheels touched. At the instant of their starting, a fly which was perched on the front wheel of one of the bicycles, started to fly towards the other at a speed of fifteen miles an hour. He flew until he touched the other front wheel and instantly started back, always at the same speed, till he touched the front wheel of the first, and so on, flying back and forth between the wheels until he was crushed as they met. How far did the fly fly?

Solution by W. E. Buker, Leetsdale High School, Leetsdale, Pa.

It is possible to approximate a solution (after the expenditure of considerable energy) by means of series. This would be the obvious method.

However, there is a much easier solution. Since the road is twenty miles long and the rate of the cars is 10 miles per hour, the time they will travel is one hour. The fly travels 15 miles per hour during the same time, and so travels exactly 15 miles.

P. S.—I don't know who originated this problem, but see Sanford "The History and Significance of Problems in Algebra" page 66.

Correct solutions to 646 were received also from J. O. Austin, Cowden community H. S., Cowden, Ill.; H. Hansen Smith, Battle Creek H. S., Battle Creek, Iowa; Irving T. Soudek, Hirsch H. S., Chicago, Ill. and Walter E. Hauswald, Beardstown H. S., Beardstown, Ill.

In answering 646, J. O. Austin said: "I am bidding for GQRA by submitting an answer to problem 646." *Elected!*

THE CANNON BALL PROBLEM

636. *Proposed by the Senior Physics Class of The Norwich Free Academy, Norwich, Connecticut,* Harold Geer, Secretary.

Our Senior Physics Class has heard of the distinguished place of SCHOOL SCIENCE AND MATHEMATICS in High School Science; and also of your department of "Questions and Answers."

Recently a problem was brought up in our Physics class which captured our imagination. We would appreciate an expression of your opinion on

this problem. It might be of interest for your "Question and Answer" department.

If from Norwich, Connecticut, a twelve-pound shot were dropped through the center of the earth; (a) where would it come out, and (b) what would happen to it on its journey?

Answer to the problem of the Norwich Free Academy by Walter E. Hauswald, Beardstown, Illinois.

(*a*) A 12-lb. shot dropped into a hole through the earth's center would not pass entirely through the earth, but would tend to assume an oscillating position about the earth's center of gravity, which is probably not a fixed point, but a moving point depending upon the effect of other bodies in the universe.

(*b*) The supposed intense heat of the earth would probably cause the metal to be melted, and if oxygen were present, the iron or lead shot would be oxidized.

In answering 636, Margaret Joseph of Shorwood H. S., Milwaukee, Wis. says:

"The ball would pass through the center of the earth oscillating, or bounding, back and forth until it would finally come to rest at the center of the earth."

Sara Chase, Hirsch High School, Chicago says in answer to 636:

"It is impossible to drop a twelve-pound shot *straight* through the center of the earth. Suppose that a hole twenty miles in diameter were dug through the earth from Norwich. If the shot were dropped through this hole it would take the direction of the plumbline at that point and the plumbline does not point directly toward the center of the earth at Norwich. It points toward a point which is over six miles from the earth's center. This is due to the oblate shape of the earth and to the centrifugal force due to rotation of the earth. The only places where the gravitational force is directly toward the center are at the poles and at the equator. Norwich is about 72° 15′ west and 41° 30′ north. As the shot falls it would curve toward the center gaining speed and momentum. It would pass through the center and continue until its speed was reduced to zero by the opposing gravitational force. Then it would be pulled back toward the center and continue to oscillate with gradually reduced amplitude until it would come to rest at the center."

HOW COLD IS ICE?

645. *Proposed by A. M. Shofner, Shelbyville 6, Tenn.*

Freeze a Fahrenheit thermometer in a block of 100 lbs. ice. Though our temperature would go to 110° in summer, it would still stand at 32°. Then in case we throw the block of ice out into the yard in winter, and our mercury goes to 10° below zero—what will the thermometer then show in the ice?

Answer by Walter E. Hauswald, Beardstown, Ill.

Continued exposure of the block of ice containing the thermometer to a temperature of ten below zero Fahrenheit would cause the thermometer to read ten below. However it would require some time for the ice, which is a poor conductor of heat, to give off the heat contained at the temperature of thirty-two degrees Fahrenheit.

GQRA—ELECTIONS—MAY, 1934

21. Samuel Strauss, Garfield, H. S., Akron, Ohio.
22. W. E. Buker, Leetsdale Public Schools, Leetsdale, Pa.
23. J. O. Austin, Cowden Community H. S., Cowden, Ill.
24. H. Hansen Smith, Battle Creek H. S., Battle Creek, Iowa.
25. Irving T. Soudek, Hirsch H. S., Chicago, Ill.
26. David Gordon and Physics Class, Woodbine H. S., Woodbine, N. J.
27. Margaret Joseph, Shorewood H. S., Milwaukee, Wis.
28. Sara Chase, Hirsch H. S., Chicago, Ill.

TEXTILE PRINTING AND DYEING WASTES EASILY MADE HARMLESS IN WATER

Pollution of rivers and other bodies of water by at least one type of industrial wastes, the discards of the textile printing and dyeing industries, can be easily and cheaply avoided. Foster D. Snell, Brooklyn consulting chemist, pointed out to the American Chemical Society how these waste liquors can be made harmless to fish and plant life in streams by adding to every thousand gallons four pounds of copperas and four pounds of lime, at a total cost of less than five cents for each thousand gallons.

—*Science Service*

BOOK REVIEWS

Differential Equations, by Nelson Bush Conkwright, Associate in Mathemathics, The University of Iowa. Pages xii+234. 1934. The Macmillan Company, New York. Price $1.90.

This textbook on differential equations presents the classical theories dealing with the solution and application of differential equations. Throughout the book footnotes refer the reader to selected references dealing with more complete treatment of the subject. Appendices at the end of the book treat briefly of special topics, fundamental integration formulas, and applications of integration.

The author has organized the subject with extreme care, thus enhancing the instructional value of the text, especially to the beginner. The expositions are clear, complete, and comprehensive, with adequate illustrations. The teachers of mathematics should welcome this new addition to the texts dealing with differential equations.

J. S. GEORGES

Plane Trigonometry With Tables, by William Anthony Granville, Formerly President of Pennsylvania College; Revised by Percey F. Smith, Professor of Mathematics in Yale University, and James S. Mikesh, Master in Mathematics in Lawrenceville School. Pages xi+212+43. 1934. Ginn and Company.

In this revision of Granville's Plane Trigonometry the authors retain certain characteristic features of the earlier edition, namely, the simplicity and clearness of exposition, the abundance of exercises worked out in the text, and a variety of problems covering a wide range of applications. The revision gives greater emphasis to trigonometric functions and attempts to present the functional aspect in a clear and simple manner. The applications, even those involving the use of the law of sines and the law of tangents, are so arranged as to provide computation both with and without logarithms. Trigonometric identities and equations are placed at the end of the course, a plan which seems consistent with pedagogical arrangement of the subject matter. Problems are given in which angles are expressed in degrees and minutes as well as in degrees and decimal parts of a degree, and the tables provide for either set of problems. The material is organized and presented in a manner easy for the learner to follow. The book deserves the attention of teachers of trigonometry.

G. E. HAWKINS

Second Year Algebra, by David A. Rothrock, Professor of Mathematics, Indiana University, and Martha Anne Whitacre, Head of The Department of Mathematics in Junior and Senior High Schools, Richmond, Indiana. Cloth. Pages xiv+272. Charles Scribner's Sons. New York. 1933. Price $1.12.

As usual this book opens with a few chapters of review material taken from the first year algebra course. Some new material is added presumably to keep interest alive in the event pupils become bored by the re-hashing of old subject matter. However, in the preface teachers are cautioned to use only such portions of the review material as seem necessary for the success of the pupil's future work in mathematics. Preceding the first chapter are found many review definitions.

The book contains the topics usually found in traditional second year texts. Enough material is included for a full year's work if so desired. It should be of interest to teachers who prefer the old type of algebra textbook.

C. A. STONE

An Introduction to the Teaching of Science, by Elliot R. Downing, Department of Education, University of Chicago. Pages vii+258. 1934. The University of Chicago Press. Price $2.00.

This book is a complete revision of the author's earlier book "Teaching Science In The Secondary Schools." The results of recent investigations are included in this revision and their applications in classroom use are well illustrated and explained.

The different topics treated are, "Major Goals and Specific Objectives," "Consumer and Producer Science," "Important Principles of Subject Matter," "Skill in Scientific Thinking," "Emotionalized Standards," "The Science Curriculum," "Organization In Units," "Studies of Teaching Methods," "Supervised Study," "Testing Results," and "Present Conditions." The book also contains a complete bibliography and an appendix which includes the requirements for teaching in the different states.

The author sets up a philosophy of science teaching at the outset and proceeds to develop this philosophy in the different topics treated with a thorough understanding and in a way which will help teachers apply this philosophy to their own problems of teaching. When any book in methods does that it has accomplished its purpose and should be read by every science teacher.

I. C. D.

Physical Optics, Third Edition, by Robert W. Wood, Professor of Experimental Physics in the Johns Hopkins University. Cloth. Pages xvi+846. 13×22 cm. 1934. The Macmillan Company, 60 Fifth Avenue, New York. Price $7.50

This textbook needs no introduction. Since the appearance of the first edition in 1905 it has been the standard text in physical optics and is really a source book for students of light. Mathematical theory is used when helpful but in many cases the development is merely outlined and results given. Stress is placed on the physical significance of both experimental results and theoretical deductions. Experimental studies are given prominence and in many cases descriptions of experiments are given in detail. By this plan the student is presented with pictures of optical processes rather than with mere mathematical abstractions.

The rapid developments in the field of optics in the past decade have added a wealth of new material and revised the views held a few years ago. The third edition of this text includes all of these developments. They are not inserted as separate topics or chapters but the old discussions have been re-written to eliminate obsolete matter and include the new in its proper sequence. In many respects this is a new book containing approximately 20% more material than the second edition. It is impossible here to show the extent of the revision but a few of the new topics are the recent measurements of the speed of light, descriptions of new optical instruments such as the reflecting echelon, compound interferometer, and improvements in the use of the Lummer-Gehrcke interferometer. New chapters added are on the Origin of Spectra, The Raman Effect, Resonance Radiation and Flourescence of Atoms, The Resonance and Flourescence Spectra of Molecules, The Flourescence and Phosphorescence of Solids and Liquids. Some of this material was given in the preceding edition but much of it is new.

This book is now the most complete and up-to-date text in advanced optics, valuable not only to physicists but to workers in all other fields of science where a knowledge of light is essential.

G. W. W.

The World Around Us, by S. R. Powers, Professor of Natural Sciences, Teachers College, Columbia University; Elsie Flint Neumer, Supervisor of Elementary Science, New Rochelle, N. Y.; and H. B. Bruner, Professor of Education, Teachers College, Columbia University. xix +475 pages. Cloth 1934. Ginn and Co., Boston. $1.20.

"The World Around Us" is the first book in the series to present a survey of science for junior high schools. The subject matter is presented to develop large generalizations as suggested by the 31st Yearbook, "A Program In Science Teaching." This series is considered an integral part of a twelve year program in science for the elementary and secondary schools. It is built upon a science program as advocated for the first six grades. It also provides an orientation for the special sciences in the senior high school.

The eight units in this book are, "What Is Science," "Living Things," "Water," "Air," "Soil," Energy And Changes In Composition," "Heat," and the "Relation Of Living Things To Their Environment." The units are divided into chapters. Unit and chapter approaches are used to awaken desirable interests and points of view. Concise summaries are also provided for each chapter and unit. Questions and things to do are given at the end of each chapter to stimulate experiences and contacts with scientific phenomena.

The book is well illustrated, well written and in a language pupils can understand. However, much of the science pupils are to learn must be acquired from a description of scientific principles and not from actual contacts with scientific materials and through laboratory exercises. When directions for experiments are given, the answers usually follow immediately. Is science for children to be a science of words or a science of activities? Is the method of learning to be inductive or deductive? These questions are raised to encourage teachers to examine this series and acquire the points of view presented by the authors.

I. C. D

Handbook of Frogs and Toads, by Anna Allen Wright and Albert Hagen Wright, Prof. of Zoology, Cornell University. xi+231 pages. Paper. 1933. Comstock Publishing Co., Ithaca, N. Y. $2.50.

This is one of the books in the series, "Handbook of American Natural History." There are eighty-two plates giving excellent photographs of the frogs and toads of the United States and Canada and their habitats. The common name, the scientific name, the range, the habitat, the size, the general appearance, the structure, the voice, and its breeding characteristics are given for each species. An additional division called "Notes" gives the experience of forty-five or fifty workers in the field of zoology. These notes also give additional observations by these workers including general habits, experiences in collecting the frogs, their enemies, their usefulness and occasionally a comparison with closely related forms.

A "key to families" gives a complete description of each family. Numbers are used in diagrams to assist in recognizing facts. The book also contains a very complete bibliography and index. Handbooks like these are of great help to teachers and pupils and should be available in all of our schools libraries as well as the personal libraries of teachers.

I. C. D.

Mystery Experiments and Problems for Science Classes and Science Clubs, by J. O. Frank, Professor of Science Education and Head of the Chemistry Department, Wisconsin State Teachers College, Oshkosh, Wis-

consin, and assisted by Guy J. Barlow, Principal of the McKinley Junior High School, Appleton, Wis. Cloth. Pages ix + 187. 12×17.5 cm. 1934. J. O. Frank and Sons, Oshkosh, Wisconsin. Price $2.25.

This book contains a collection of experiments which are interesting and thought-provoking. They may be used for lecture demonstration, as mystery problems on Science Club Programs, and as "stunts" for the "Science Fair" or the "Open House Exhibit." The index serves at the same time as a table of contents and lists 130 topics nearly all of which are in experimental form. Sixty illustrations add much to enlarge and clarify the directions and to bring out the essential technique of the performance.

The book is divided into two parts. Part I consists of stunts and mystery demonstrations; Part II includes unusual or unique demonstration experiments. In each part the experiments are grouped for physics and for chemistry respectively.

A number of the experiments are standard demonstrations which are already known to experienced teachers. The Cartesian diver, radiant energy, the singing flame, the geyser, the fountain, burning air, are examples, although familiar, their demonstration value is brought out to advantage. Several experiments are exceptional because they are unique and instructive, such as, spontaneous combustion, the restless marbles, the climbing spark, the gas detector, the dust explosion, and the smoke consumer.

The outstanding feature of this book lies in the numerous "stunts"; these present a strong element of mystery. Their chief value lies in the fact that they are presented to be solved ultimately; they set up a problem which is a challenge for a scientific solution; in general they are more entertaining than instructive. They belong in the playground of science departments.

In a sense the ideas embodied in this book of experiments is an important challenge to us that we have thus far touched in only a very limited way the great possibilities of teaching by demonstration. When we consider the wealth of instructive material which is available in all sciences there is really no reason why any science course should not be made interesting; in fact, even without introducing any mystery features, the essentials of science subjects can be made intensely dramatic.

It is hoped that these mystery experiments will be the forerunner of increased literature in the art of science demonstration. Every professional library for teachers should contain this book. Science teachers everywhere will want a copy to assist them in developing enthusiasm and an atmosphere of scientific insight in their classes.

W. F. Roecker

BOOKS RECEIVED

Differential and Integral Calculus, by Clyde E. Love, Professor of Mathematics in the University of Michigan. Third Edition. Cloth. Pages xv + 383. 12.5×19 cm. 1934. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price. $2.75

A History of Mathematics in America Before 1900, by David Eugene Smith, Professor Emeritus of Mathematics, Teachers College, Columbia University, and Jekuthiel Ginsburg, Professor of Mathematics in Yeshiva College, New York. Cloth. Pages x + 209. 12.5×19 cm. 1934. The Open Court Publishing Company, 149 East Huron Street, Chicago, Illinois. Price $2.00.

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The World Around Us, by Samuel Ralph Powers, Professor of Natural Sciences, Teachers College, Columbia University; Elsie Flint Neuner, Supervisor of Elementary Science, New Rochelle, New York; Herbert Bascom Bruner, Professor of Education, Teachers College, Columbia University. Cloth. Pages xix+475. 12.5×19.5 cm. 1934. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price. $1.20.

Work-Test Book to Accompany The Nations at Work, by Bruce Overton. Paper. Pages ii+141. 20×28 cm. 1934. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 40 cents.

First-Year Algebra, by Herbert E. Hawkes, Professor of Mathematics in Columbia University; William A. Luby, Head of the Department of Mathematics in the University of Kansas City; Frank C. Touton, Professor of Education in the University of Southern California. Cloth. Pages vii+482. 13×19 cm. 1934. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price. $1.32.

Trees and Shrubs of Minnesota, by Carl Otto Rosendahl, Professor of Botany, and Frederic K. Butters, Associate Professor of Botany, University of Minnesota. Cloth. Pages vii+385. 17×25.5 cm. 1928. The University of Minnesota Press, Minneapolis, Minn. Price $4.00.

Manual for the Identification of the Birds of Minnesota and Neighboring States, by Thomas S. Roberts, Professor of Ornithology and Director of the Museum of Natural History, University of Minnesota. Linen. Pages xiii+280. 15.5×23.5 cm. 1932. The University of Minnesota Press, Minneapolis, Minn.

Directed Geography Study, Book Three, by Robert M. Brown, Rhode Island College of Education, and Mary Tucker Thorp, Henry Barnard School, Rhode Island College of Education with the coöperation of Winifred Ellen Gleason, Henry Barnard Junior High School, Rhode Island College of Education. Paper. 19.5×26.5 cm. Pages iv+124. 1934. World Book Company, Yonkers-on-Hudson, New York. Price 52 cents.

Everyday Science, by Carleton Estey Preston, Associate Professor of the Teaching of Science, University of North Carolina. An Outline for Schools and Women's Clubs. University of North Carolina Extension Bulletin, Volume XIII, No. 4, November 1933. Paper. 51 pages. 15×23 cm. The University Extension Division, Chapel Hill, North Carolina. Price 50 cents.

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